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Engineering Library

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VOL. CXVII.—No. 3049.] *LONDON: FRIDAY, JUNE 6, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisements, pages 35 and 45.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } ROW'S PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
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See Advertisement, page 27. 1872

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One Superior 400 Kw. Howden - Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure.
One High-Class Horizontal Side - by - Side COMPOUND CORLISS ENGINE, 200 I.HP. at 80 r.p.m., belt flywheel 12 ft. diameter by 2 ft. 6½ in. on face, very suitable for export, for driving factory, sawmill, etc.
One Powerful Set COMPOUND HORIZONTAL HYDRAULIC PUMPING ENGINES, by Sir Wm. Arrol & Co., capacity 200 gallons per minute.
Two Steamdriven CENTRIFUGAL PUMPS, by Drysdale, capacity 1250 and 1300 gallons per minute.
In new condition and all seen here at Glasgow.
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The whole of the MACHINERY, TOOLS, PLANT, Etc., of GOVAN ENGINE WORKS (lately belonging to Messrs. DUNSMUIR & JACKSON, Limited,)
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For particulars apply 180, Hope Street, Glasgow.
D431

For Sale.—Floating Electric POWER STATION. 1000 Kw., with Parsons Geared Turbines, and Generators D.C. 110/575 volts and A.C. 230/7600 volts. Steam from 6 Oil-fired Boilers. Installed on Barge 165 ft. by 25½ ft. with workshop and storeroom. Also Fuel Oil Steel Barge of 80 tons capacity, and 500 Kw. Vickers Rotary Converter and Transformer converting A.C. into 440 volts D.C.
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Technical Translations from or into Spanish, Italian, French, German, Russian, &c., by experts.—VICTORIA TRANSLATION BUREAU, 51a, Southampton Bldgs., Chancery Lane, W.C. 2.

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See Advertisement page 62, May 30. 2402

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See Full Page Advt., page 63, May 23.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 60, May 23. 6196

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NEWBURY, ENGLAND. 1881

WAYGOOD-OTIS LIFTS 2130
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Diesel Engines, 300, 530, 800, 1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
HICK DIESEL OIL ENGINES, LTD., 70, Queen Street, E.C. 4. 2043

To Save Weight — and Avoid Rust — Employ Aluminium.
Data from British Aluminium Co., Ltd., 109, Queen Victoria St., London. 1908

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

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Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Civil Service Commission.

—FORTHCOMING EXAMINATION. MALE CARTOGRAPHER in the Hydrographic Department of the Admiralty (19—25, with extension in certain cases), 10th July.

The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from THE SECRETARY, Civil Service Commission, Burlington Gardens, London, W.1. D 899

B.Sc. Engineering.

A Special RECAPITULATION ORAL COURSE of Two Weeks' duration, commencing JUNE 23rd next, to JULY 5th, will be given in London during both day and evening, by Two Experienced Lecturers, to students who are taking the B.Sc. Examination in Engineering.—For further particulars, address, D 980, Offices of ENGINEERING.

Engineering Exhibition.

Under the auspices of the South Wales Institute of Engineers.

DRILL HALL, (Dumfries Place), CARDIFF, NOVEMBER 27th to DECEMBER 6th, 1924 (both dates inclusive).

The Council of the South Wales Institute of Engineers INVITES APPLICATIONS for SPACE in the above Exhibition. The last date for receiving applications is August 30th, 1924.

The Drill Hall has been booked from November 20th to December 13th, so as to allow sufficient time for the erection and removal of exhibits.

The Exhibition will be open from Two p.m. to Eight p.m. each day, except Friday, December the 5th, when it will close at Six p.m.

SCHEDULE OF EXHIBITS.

RECORDING INSTRUMENTS, ETC.,

Scientific, Measuring and Recording Instruments, as applied to all branches of Engineering.

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Water Softening and Cooling Plant.
Boilers and Equipment.
Pipes, Valves, Separators, etc.
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Motors of various kinds and Models of Winders.
Switchgear, Cables, Controllers, etc.
Electrical Tools and other Appliances.
Overhead lines.
Small Motors.
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Telephone and Wireless Apparatus, etc.

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Mechanical Transmission of Power above and below ground, and plant and equipment connected therewith.
Bearings, Clutches, Ropes, Belts, Gearing, etc.
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Machine Tools (Small).
Pneumatic Tools.
Hydraulic Tools, etc., etc.

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Shaft Signalling.
Devices to prevent overwinding.
Models of Pit-Cages, Tram Tipplers and Decking Devices.
Models of Coke-Ovens, By-Product and Recovery Plant.
Coal-Cutting and Conveying Machines.
Pumping Plant.
Models of Screening, Coal Washing and Stone Dusting Plant.
Couplings.

Exhibitors will be allowed to group their Exhibits on one Stand, when exhibiting under more than one Section.

Forms of Application for Space, Ground Plan and other particulars will be forwarded on application to MARTIN PRICE, Secretary, The South Wales Institute of Engineers, Park Place, Cardiff. D 988

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

T. G. Howes Thomas, (Inst.

C.E. Coach, late of Westminster), Consulting Engineer, has resumed his "Up-to-date" Coaching by correspondence, and is prepared to advise on proposed or accepted patents.

34, Baldwin Street, Bristol. D 847

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2, invite

Tenders for:—

1. SHEFFIELD TOOLS, &c. ... ... Fee 5/-

Tenders are due by Eleven a.m. on 17th June, 1924. Tender forms available at above address. Fees not returnable. D 975

METROPOLITAN ASYLUMS BOARD.

TO ENGINEERS, ELECTRICIANS AND OTHERS.

The Board invite separate

Tenders for :—

(A) INSTALLATION of 144-TUBE ECONOMISER.
(B) INSTALLATION of NEW CONTINUOUS DRYING MACHINE.
(C) ENGINEERING WORK for NEW CENTRAL BOILERHOUSE.
(D) REVISION of LAUNDRY ENGINEERING ARRANGEMENTS.
(E) INSTALLING ELECTRIC LIGHT AND POWER WIRING in Boilerhouse and Laundry.
(F) COVERING of BOILERS, STEAM, FEED AND SUCTION MAINS, etc., with Non-conducting Composition.

at the South Western Fever Hospital, Landor Road, Stockwell, S.W. 9,

each in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Friday, 6th June, 1924, and can then be obtained on payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender, and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 18th June, 1924.

(By Order) G. A. POWELL,
Clerk to the Board. D 963

BIRKENHEAD UNION.

The Guardians of the Birkenhead Union invite

Tenders from Heating and Hot

WATER ENGINEER for the SUPPLY, DELIVERY and ERECTION at the Union Institution and Infirmary, Derby Road, Tranmere, Birkenhead, of approximately 250 RADIATORS, HOT WATER and HEATING PIPING, MAINS and ACCESSORIES, forming an extension of the Centralised Heating System.

Copies of the General Conditions, Specification and Plans, and forms of Tender may be obtained from the Consulting Engineers, Messrs. SLOAN AND LLOYD BARNES, M.I.Mech.E., 34, Castle Street, Liverpool, on payment of a deposit of Two Guineas (£2 2s. 0d.), which deposit will be returned on receipt of a *bona-fide* Tender.

The persons whose Tender is accepted will be required to enter into a contract with the Guardians and to provide sureties for its due performance.

The Contractor in carrying out the Contract will be required to pay the rates of wages and observe the hours of labour recognised and agreed upon between the Employers and the Trades Unions in the district. He will also be required to comply with the conditions of the Unemployment Grants Committee in regards to the employment of suitable local (Birkenhead and Wallasey) unemployed persons—75% of whom must be ex-Service men.

Inquiries (if any) should be addressed to the Engineers.

Tenderers are requested to furnish a statement of recent similar work carried out by them.

Canvassing the Guardians directly or indirectly will be deemed a disqualification.

Tenders, sealed and endorsed "EXTENSION TO CENTRALISED HEATING SYSTEM," and addressed to the undersigned, must be delivered before Twelve o'clock Noon on Tuesday, the 24th day of June, 1924.

By Order,
S. R. CARTER,
Clerk to the Guardians.

Poor Law Offices,
Conway Street,
Birkenhead. D 954

METROPOLITAN WATER BOARD.

TENDERS FOR THE MANUFACTURE, DELIVERY AND FIXING OF THREE ELECTRICALLY DRIVEN RECIPROCATING AIR COMPRESSORS AND TWO ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS, PIPING, FITTINGS, ETC., AT WALTON PUMPING STATION, SURREY.

The Metropolitan Water Board invite

Tenders for the Manufacture,

DELIVERY AND FIXING OF THREE ELECTRICALLY DRIVEN RECIPROCATING AIR COMPRESSORS AND TWO ELECTRICALLY DRIVEN CENTRIFUGAL PUMPS, PIPING, FITTINGS, ETC., AT THE WALTON PUMPING STATION, SURREY.

Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected without payment of fee at the Offices of the Board (Room 173), Chief Engineer's Department, on and after Friday, 6th June, 1924.

Contractors desirous of Tendering may obtain the necessary documents from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of One guinea, which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona fide* Tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board," and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C.1," and endorsed "Tender for Air Compressors, etc., Walton," must be delivered at the Offices of the Board not later Ten a.m. on Wednesday, 2nd July, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C.1.
2nd June, 1924. D 971

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES:—

1. STEEL BOILER TUBES for Locomotives.
2. BRASS BOILER TUBES for Locomotives.
3. CRANK AXLES for Locomotives.
4. STEEL TYRES for Locomotives.

Tenders due on the 17th June, 1924, for Nos. 1 and 2 and on the 20th June, 1924, for Nos. 3 and 4.

Tender forms obtainable from the above. D 967

METROPOLITAN ASYLUMS BOARD.

TO MAKERS OF WEIGHBRIDGES.

The Board invite

Tenders for Providing and

FIXING a NEW 20-ton WEIGHBRIDGE, at Tooting Bec Mental Hospital (Extension), Tooting, S.W.17, in accordance with the Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Friday, 6th June, 1924, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned.

Tenders addressed as noted on the Form, must be delivered at the office of the Board not later than 2.30 p.m. on Wednesday, 18th June, 1924.

(By Order) G. A. POWELL,
Clerk to the Board. D 978

METROPOLITAN ASYLUMS BOARD.

To MARINE ENGINEERS and SHIP REPAIRERS.

The Board invite

Tenders for :—

RE-CAULKING the DECKS of T.S. "EXMOUTH," lying off Grays, Essex,

in accordance with the Specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Wednesday, 4 June, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification has been returned.

Tenders addressed as noted on the Form must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 18 June, 1924.

(By Order) G. A. POWELL,
Clerk to the Board. D 946

STATE ELECTRICITY COMMISSION OF VICTORIA,
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, ELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/38—
BUSHING INSULATORS
FOR 6600 V. TRIFURCATING BOXES.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona-fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £10 is to be lodged with Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than Five p.m., 15th September, 1924.

R. LIDDELOW,
Secretary. D 956

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/45—
66,000 VOLT INSULATORS.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10/6 each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 4th August, 1924.

R. LIDDELOW,
Secretary. D 833

COUNTY BOROUGH OF ST. HELENS.

REDGATH BRIDGE.

The Corporation of St. Helens are prepared to receive

Designs and Tenders for the

CONSTRUCTION in STEEL and ERECTION of a new MOVABLE BRIDGE in lieu of the existing Swing Bridge over the Canal at Redgate within the Borough.

Plan of site and particulars may be obtained on application to Mr. ARTHUR W. BRADLEY, M.Inst. C.E., the Borough and Water Engineer, St. Helens.

Sealed Tenders, on the form and in the envelope provided, to be delivered on or before the 30th day of June.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW,
Town Clerk.

Town Hall, St. Helens.
May, 1924. D 878

VICTORIAN STATE RAILWAYS.

THE AGENT-GENERAL FOR VICTORIA, AUSTRALIA, invites

Tenders for the Supply

and DELIVERY C.I.F., Melbourne, fully inclusive of Australian Customs Duties, etc., of the following:—

CONTRACT 36853.

Approximately 3155 tons 80 lbs. STEEL RAILS,
2368 tons 100 lbs. STEEL RAILS,
95 tons FISHPLATES for 80 lbs. Rails.
153 tons FISHPLATES for 100 lbs. Rails.

Tenderers have the option of tendering F.O.B. British Port basis.

Specifications, Conditions of Contract and Forms of Tender may be obtained by *bona fide* Tenderers at the Offices of the Consulting Engineers, Messrs. JOHN COATES & Co., LTD., Victoria House, Melbourne Place, Strand, London, W.C.2.

Tenders must be delivered to THE AGENT-GENERAL FOR VICTORIA, Victoria House, Melbourne Place, Strand, London, W.C.2, not later than Noon on Wednesday, June 25th, marked "Tender for Steel Rails."

A preliminary deposit of Ninepence per ton must accompany each Tender.

The Government does not bind itself to accept the lowest or any Tender.

Signed, JOHN McWHAE
Agent-General for Victoria.

Victorian Government Office,
London. D 970

APPOINTMENTS OPEN.

Chief Chemist, Temporary or

Permanent, REQUIRED for Portland Cement Factory in Australia. Applicants must have first-class experience with modern Rotary Kilns operating on the Thick Slurry Process. Free quarters and allowances provided.—Apply, stating fully experience, age, and salary, to W. J. C., EDGAR ALLEN & Co., Ltd., Imperial Steel Works, Sheffield. D 963

Manager for Iron and Steel

Tube Trade; must have good testimonials and wide experience. State salary required.—Address, D 969, Offices of ENGINEERING.

Works Manager, Really High-

Class REQUIRED for Modern Engineering Works in West Riding, Yorkshire. Must have organising abilities, able to control workmen and foremen, and have held similar successful position. State fullest particulars.—Address, D 943, Offices of ENGINEERING.

GREAT INDIAN PENINSULA RAILWAY COMPANY.

VACANCY FOR ASSISTANT BRIDGE ENGINEER.

Applications are Invited from

duly qualified Candidates for the above APPOINTMENT in India.

GENERAL QUALIFICATIONS. — Candidates, who should be between the ages of 26 and 32, should have had a first-class education and subsequent training and experience in Bridge design and construction and structural steelwork with a British Firm of Bridge Builders. The Candidate appointed would be required to deal with preparation of detail drawings, calculations, etc., and experience of ferro-concrete design is desirable.

The selected Candidate will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

TERMS.—The appointment in the first instance will be for three years under agreement, but may subsequently be extended by arrangement. The Company will provide a First-class passage to India. The selected candidate will be required to work at any Station on the Company's System as may be directed by the Chief Engineer.

SALARY.—The initial salary will be fixed according to qualifications, with a minimum, inclusive of an Overseas Allowance of Rupees 150 per month, of Rupees 550 per month, rising by annual increments of Rupees 50 per month to a maximum in this grade of Rupees 1150 per month.

Salary will commence upon the date of sailing for India.

The Engineer appointed will be entitled to the benefits of the Railway Provident Fund and details of this, together with particulars of the Leave, Rules, rental of quarters, etc., will be supplied on application.

Forms upon which applications for the appointment must be made, may be obtained on written request to Messrs. ROBERT WHITE & PARTNERS, the Company's Consulting Engineers, 3, Victoria Street, London, S.W.1, to whom the forms must be returned on completion. D 979

12,000-KW. STEAM TURBO-GENERATOR AT THE BRITISH EMPIRE EXHIBITION.

AMONGST the most striking engineering exhibits at Wembley must be classed that of Messrs. C. A. Parsons and Company, Ltd., of the Heaton Works, Newcastle. The steam turbine specialist will no doubt be most attracted by the model of the remarkable 50,000 kw. turbine which is now being completed for Chicago, but the engineer interested in power stations of average capacity will probably devote more attention to the 12,000-kw. machine, which is one of five similar machines built for the Colenso power station of the South African Railways and Harbours Administration.

The first part of the scheme for the electrification of the South African railways provides for the conversion of an existing line in Natal between Pietermaritzburg and Glencoe. A coal-fired electric generating station, in which steam turbines will supply the motive power, is being built at Colenso, on the River Tugela. The arduous conditions of service which inevitably attend the supply of power for electric railway traction, owing to the exposed network of conductors, render necessary the most robust construction for the generating plant, and the main features of the design finally adopted by the builders, and approved by the consulting engineers, Messrs. Merz and McLellan, will be readily grasped in reference to the general arrangement, Fig. 1, above, and the longitudinal and cross sections, Figs. 5, 6 and 7, Plate LXXIII, to which detailed reference will be made later.

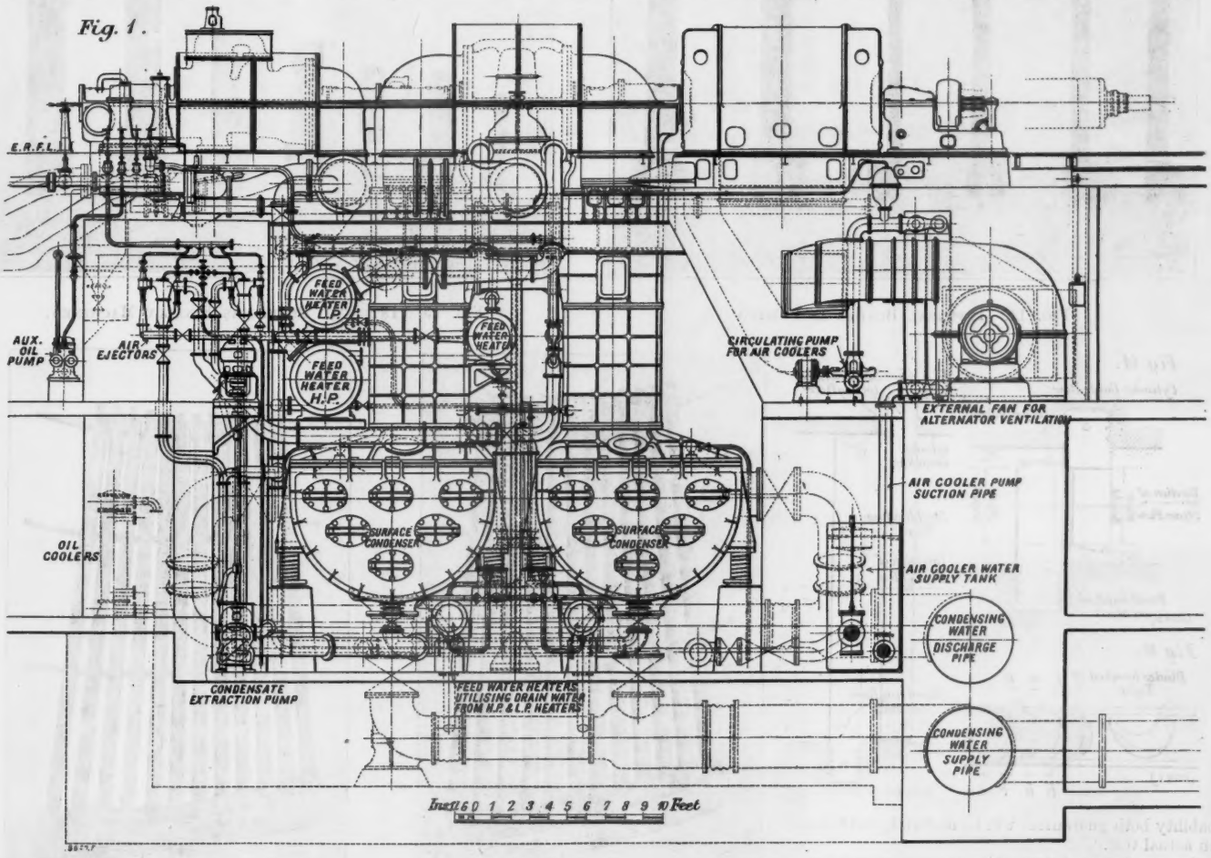
The turbines, which embody the all-reaction tandem cylinder design, are of a type which has been consistently developed by the Parsons company since the year 1900, when the famous Elberfeld 1,000-kw. 1,500-r.p.m. tandem plants were built. Double-ending of the blading, which was incorporated even in the first Parsons turbine of 1884, had subsequently been developed in the case of exhaust steam turbines to enable them to deal with larger volumes of exhaust steam, and was afterwards applied to the low-pressure cylinders of tandem turbines with the same object. This type of tandem turbine, with double-ended low-pressure cylinder, was first adopted in the 20,000-kw. 750-r.p.m. Chicago plant of 1913 (ENGINEERING Vol. xcvi, page 513); and was afterwards also used for the 15,000-kw. 1,000-r.p.m. Lots Road turbine of 1914 (ENGINEERING, Vol. 103, page 465), and for the six turbo-alternators for the 25 period, 64,000-kw. generating station at Newport, Victoria, Australia, laid down by the Victorian Railways Commissioners for the electrification of the Melbourne Suburban Railways. That station was commenced in 1913, and was originally designed for six 10,000-kw. (normal rating) tandem turbo-alternators running at 1,500 r.p.m. At the conclusion of the war, four of these had been supplied and the remaining two commandeered for the new power station at Rotherham. Two new machines had therefore to be built to complete the Melbourne contract, and the design for these was modified to enable an economical output of 12,000 kw. to be obtained. In 1921, the State Electricity Commission of Victoria decided to lay down a 50-period plant for supplying general power requirements in Melbourne, and two 15,000 kw. sets were built in an extension of the same building, called the Newport "B" station. The experience accumulated by the Parsons Company during the period 1915-1921 enabled them to take advantage of the increased periodicity and to design the new machines to run at the maximum permissible speed, namely, 3,000 r.p.m.

For the new traction power station at Colenso the speed of rotation will be 3,000 r.p.m., and the operating steam conditions will be 250 lb. gauge pressure at the stop valve, with an initial temperature of 700 deg. F. (giving 294 deg. F. initial superheat). The normal condenser vacuum, which is based on a cooling water temperature of 70 deg. F., will be 28½ in. (bar., 30 in. of mercury). Under these conditions, the guaranteed steam consumption at the economical load (12,000 kw.) is 10·30 lb. per kw.-hour, giving a terminal efficiency ratio of 74·65 per cent.

On the complete turbine there are 38 rows of moving blades in series, and the value of the coefficient "K," or the integral of the values of $\left(\frac{d}{10}\right)^2 \left(\frac{\text{R.P.M.}}{100}\right)^2$ throughout the turbine is 363,000, so that the mean velocity ratio (uncorrected for reheat or for supersaturation losses) at normal load is 0·79. Approximately three-fifths of the output is developed by the high-pressure cylinder and one-fifth in each half of the low-pressure cylinder.

The guaranteed steam consumption, stated above, is based on the assumption that no steam is withdrawn from the turbine for feed water heating. It will be seen from the elevation (Fig. 1 on this page), however, that arrangements are made for heating the feed-water by means of surface heaters in series, four successive stages being used to heat the condensate on its way to the feed pumps. In the first stage, assuming full load is on the turbine, the condensate will be heated from 88 deg. F. up to 93 deg. F. by means of the heat recovered from the drain water from the succeeding heaters. Two surface heaters in series on the condensate side will be used for this purpose, each one discharging cooled drain water through a trap into the condensers. The traps will be arranged so that both heaters will be constantly flooded with drain water. The condensate or feed water will then pass through the low-pressure heater, which will raise the temperature to 135 deg. F. At this stage the steam from the secondary nozzles of the air ejectors will be utilised in a further surface heater, the temperature being raised to 145 deg. F. Steam will then be tapped off into the fourth stage heater from the interconnecting pipes between the high-pressure and low-pressure turbine cylinders, raising the feed water temperature to 180 deg. F., after which the feed water will enter the boiler feed pumps. These pumps will deliver the feed water to the boilers through another surface heater, taking exhaust steam from the pumps, and the final feed water temperature will thus be raised to 210 deg. F. There will be no feed water economisers in the

Fig. 1.


E.R.F.L.
AUX. OIL PUMP
AIR EJECTORS
FEED WATER HEATER L.P.
FEED WATER HEATER
FEED WATER HEATER H.P.
CIRCULATING PUMP FOR AIR COOLERS
EXTERNAL FAN FOR ALTERNATOR VENTILATION
AIR COOLER PUMP SUCTION PIPE
OIL COOLERS
SURFACE CONDENSER
SURFACE CONDENSER
AIR COOLER WATER SUPPLY TANK
CONDENSING WATER DISCHARGE PIPE
CONDENSATE EXTRACTION PUMP
FEED WATER HEATERS UTILISING DRAIN WATER FROM H.P. & L.P. HEATERS
CONDENSING WATER SUPPLY PIPE
Inset 0 1 2 3 4 5 6 7 8 9 10 Feet

boiler plant, the flue gases being utilised instead to heat the incoming furnace air. When the heaters taking steam from the turbine are in use, and the specified feed-water temperature is attained at the exit from the fourth stage, the guaranteed steam consumption at the economical load is 10·60 lb. per kw.-hour. This steam rate, though greater than that under the guaranteed conditions, corresponds nevertheless to a materially higher overall thermal efficiency, and a study of the drawings leads to the conclusion that in all probability both guarantees will be materially bettered on actual test.

A general view of the turbine in course of erection in the makers' shops is reproduced in Fig. 2, Plate LXXII, whilst Figs. 3 and 4 on the same Plate show respectively the high- and low-pressure rotors complete and ready to go into place.

Each rotor is machined out of a single solid steel forging, which is bored from end to end, thus affording the opportunity of ascertaining the quality of the metal at the centre. There are no loose parts or discs. As best seen in the longitudinal section (Fig. 5, Plate LXXIII), large gaps are machined out of the low-pressure rotor for the purpose of removing unnecessary weight and the process at the same time, provides facilities for a very comprehensive examination of the soundness of the forging.

The sectional end elevation of the turbine (Fig. 6, Plate LXXIII shows the arrangement of the governor oil pumps and strainer, and also the position of the main valves. A section through the automatic overload valve is reproduced in Fig. 7. In order to cope with the severe load fluctuations and heavy overload which are unavoidable in railway traction, each turbo-alternator is designed to take a load of 20,000 kw. for two minutes. To secure this overload capacity, the overload valve bye-passes 15 rows of moving blades, as best seen in Fig. 5, Plate LXXIII. A section through the steam chest showing the emergency governor valve and the double-beat main throttle valve is reproduced in Fig. 8. In normal running the emergency governor valve is held open by a lever against the pressure of the spring shown above it in Fig. 8. This lever is retained in position by a trigger which, should the speed rise above a pre-determined limit, is tripped by the emergency governor. The valve then closes automatically. The same lever system that releases the emergency valve also opens a valve on the oil supply system, thus destroying the pressure there. Since the main throttle valve is only held open by this oil pressure, it also closes when the emergency valve is tripped. To restart the turbine steam is admitted above the piston over the runaway valve, forcing it down against the spring pressure until it is caught and held by the lever already mentioned.

The blading of the turbines is wholly of mild steel, and the high-pressure turbine blading is "end-tightened" throughout. The principle of the "end-tightened" blading has already been fully described in ENGINEERING (page 211, August 13, 1920, also page 40, July 13, 1923).

The blading of the high-pressure turbine rotor is of special interest, being of the "integral" type, in which the blades are manufactured integral with their roots, and are formed by rolling methods recently developed by the Parsons Company at the Heaton Works. The successful manufacture of such turbine blades, by rolling methods which produce the finished profile from a steel blank, and at the same time form the blade root, is an achievement at which the Parsons Company have aimed for many years, and the success at last realised has only been attained after many efforts and much disappointment. One advantage of rolling, over other methods of producing integral blades, such as milling out of the bar, stamping or drop forging, is that the material is worked so that the grain or fibre is developed in the best direction for strength, and, further, the manufacturing process subjects the material to a strenuous test, and has been found to detect faults with considerable certainty.

A group of reaction blades as produced by these methods is represented in Fig. 12, above, as delivered from the rolls, whilst in Fig. 13 the finished blades are shown, the only machining operations employed being the finishing of the

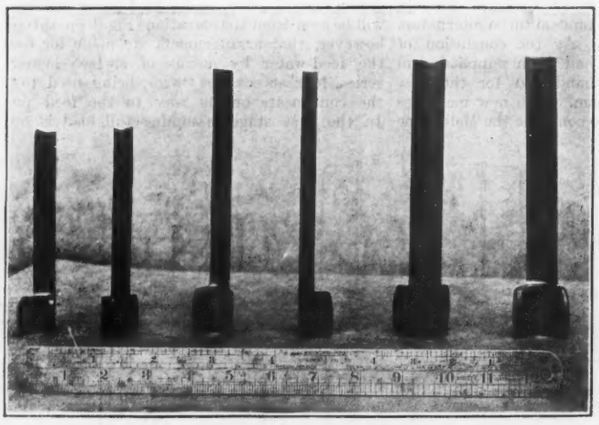


FIG. 12. INTEGRAL BLADES AS FORGED.

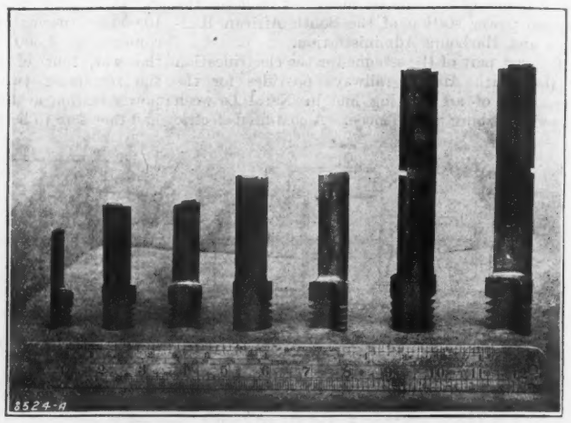
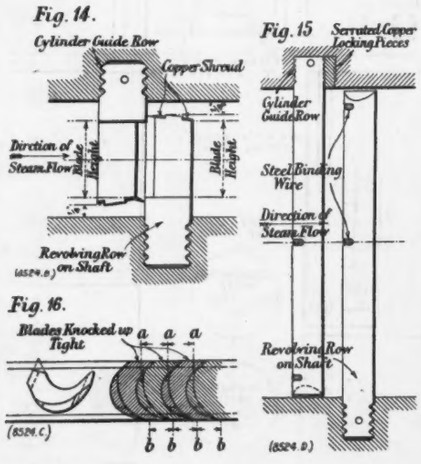


FIG. 13. INTEGRAL BLADES AS FINALLY MACHINED.



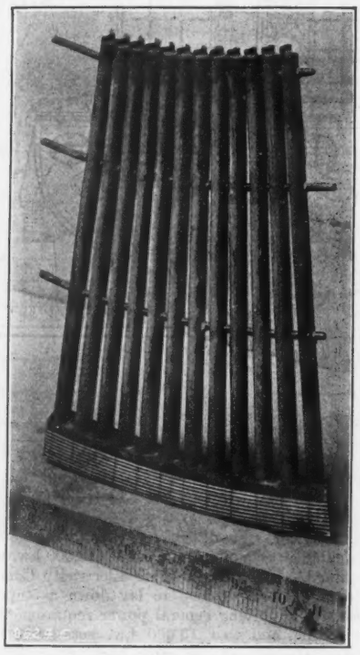


FIG. 17. SEGMENTAL BLADING FROM STEAM ADMISSION SIDE.

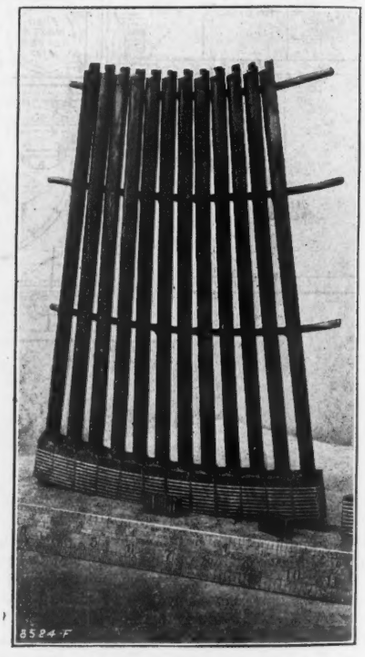


FIG. 18. SEGMENTAL BLADING FROM STEAM DISCHARGE SIDE.

(To face page 722)

12,000-KW. STEAM TURBO-GENERATOR AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. C. A. PARSONS AND COMPANY, LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 721.)

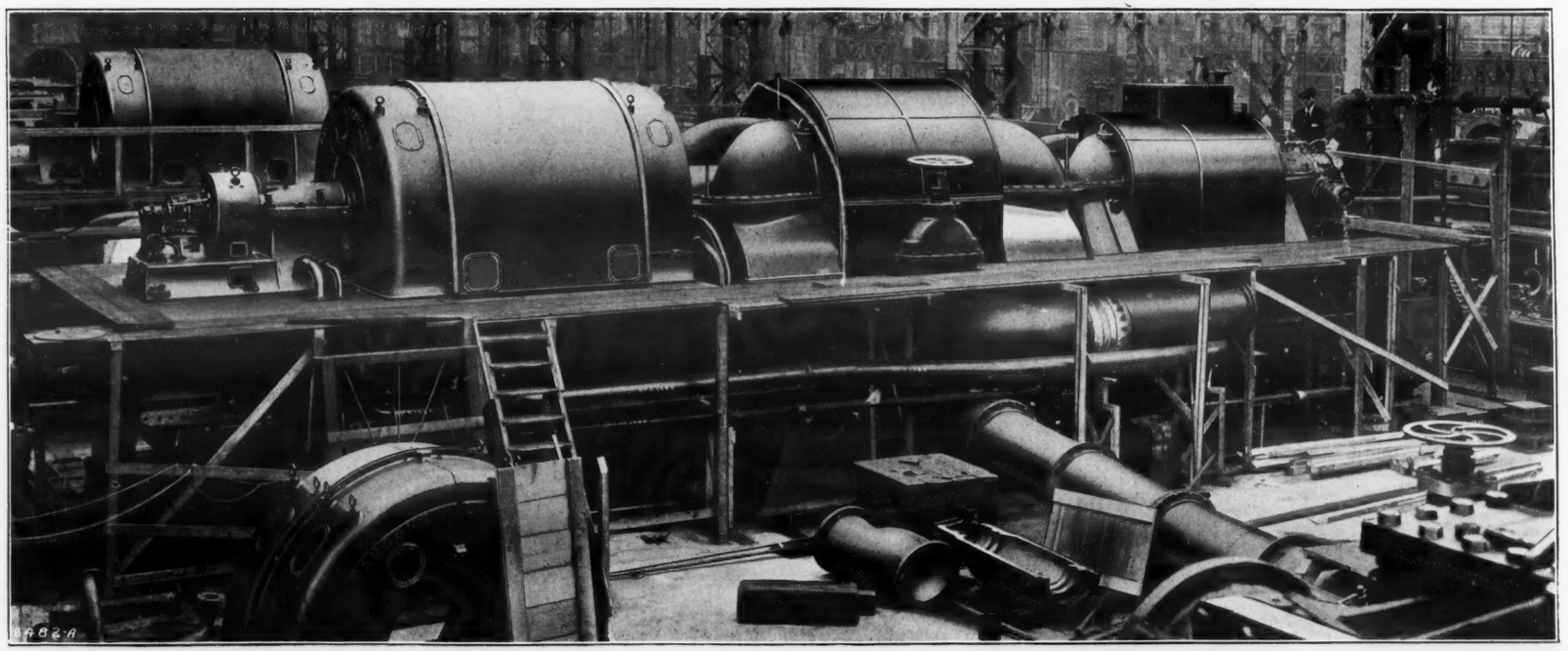


FIG. 2. VIEW OF TURBO-GENERATOR AS ERECTED IN MAKERS' SHOP.

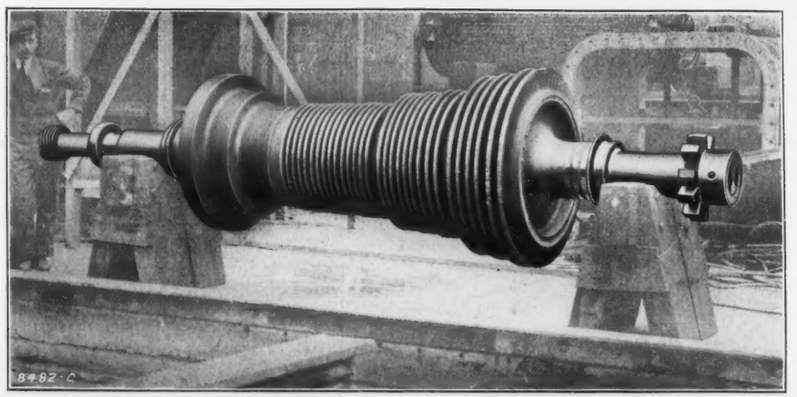


FIG. 3. HIGH-PRESSURE ROTOR.

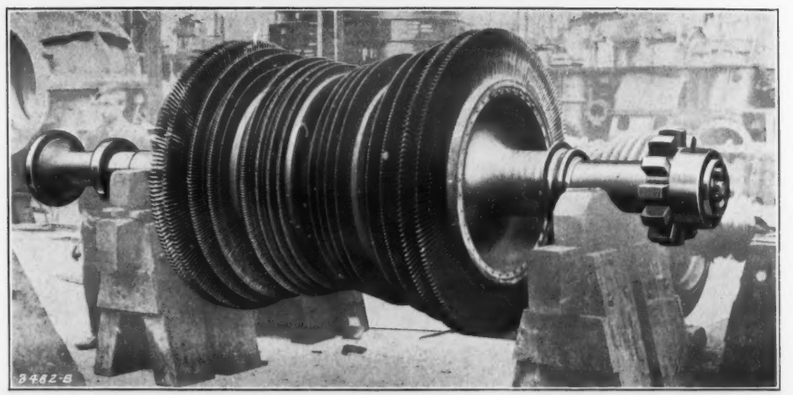


FIG. 4. LOW-PRESSURE ROTOR.

12,000-KW. STEAM TURBO-GENERATOR AT THE

CONSTRUCTED BY MESSRS. C. A. PARSONS AND COMPANY, LIMITED

(For Description, see Page 721.)

Fig. 5.

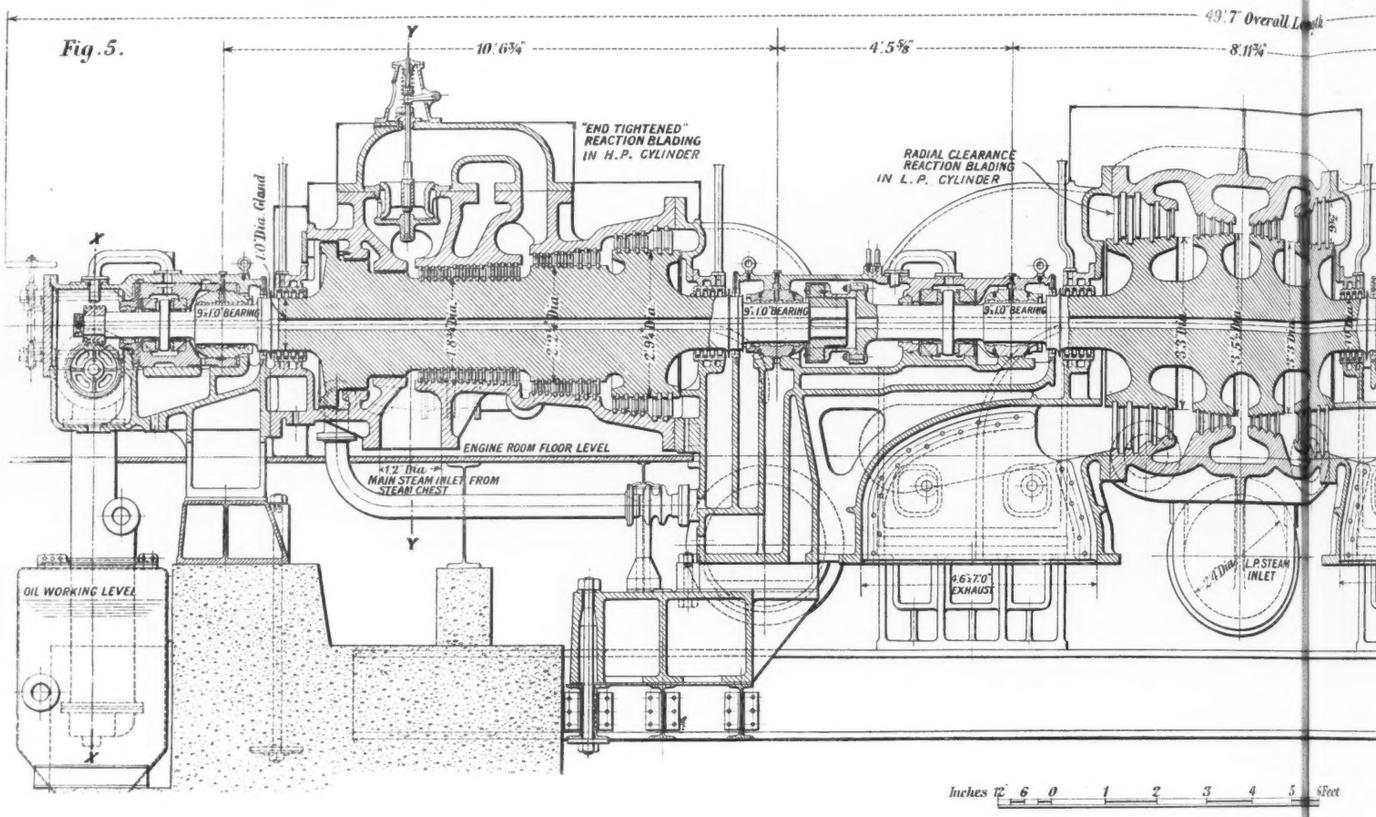


Fig. 6.
SECTION X.X.

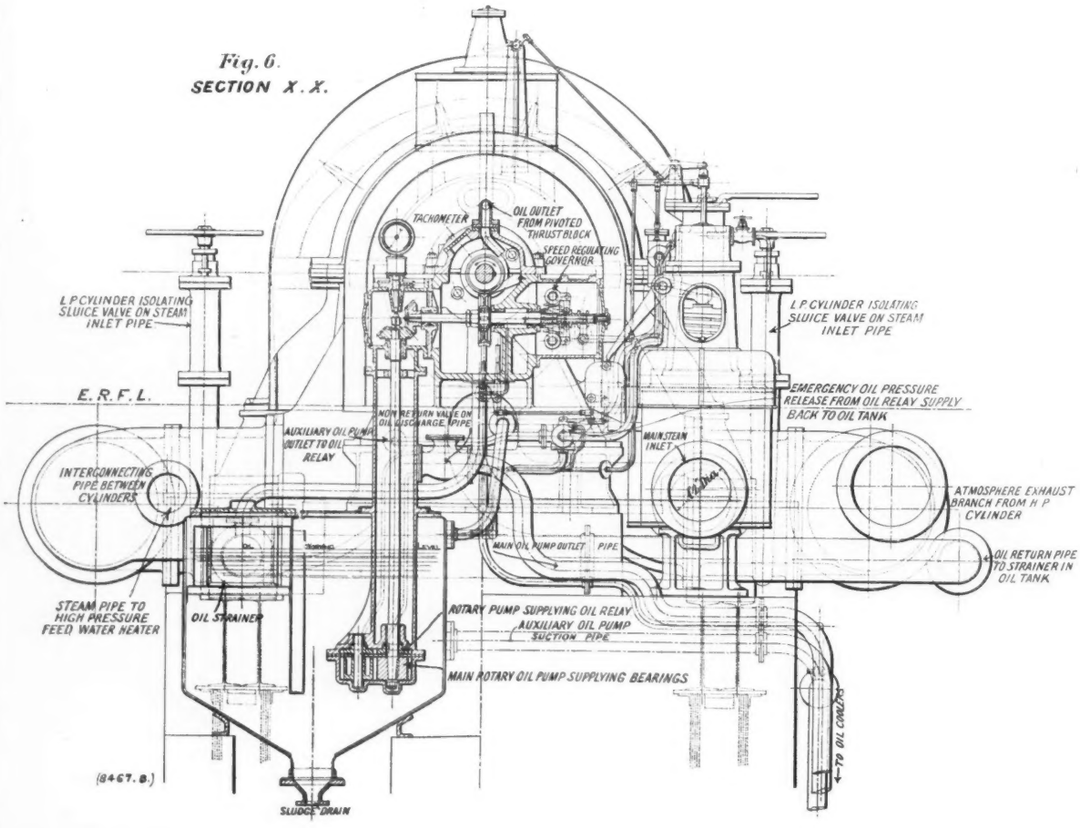
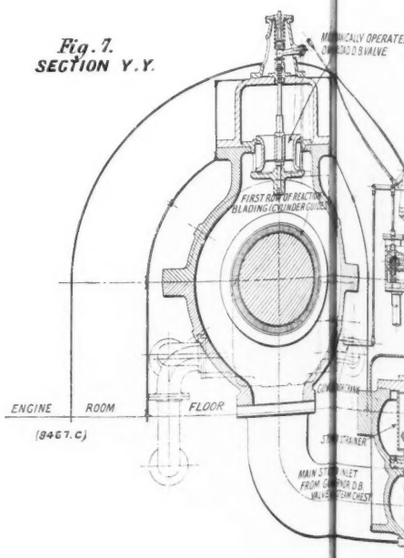

TACHOMETER
OIL OUTLET FROM PIVOTED THRUST BLOCK
SPEED REGULATING GOVERNOR
L.P. CYLINDER ISOLATING SLUICE VALVE ON STEAM INLET PIPE
L.P. CYLINDER ISOLATING SLUICE VALVE ON STEAM INLET PIPE
E.R.F.L.
EMERGENCY OIL PRESSURE RELEASE FROM OIL RELAY SUPPLY BACK TO OIL TANK
NON RETURN VALVE ON OIL DISCHARGE PIPE
AUXILIARY OIL PUMP OUTLET TO OIL RELAY
MAIN STEAM INLET
INTERCONNECTING PIPE BETWEEN CYLINDERS
ATMOSPHERE EXHAUST BRANCH FROM H.P. CYLINDER
MAIN OIL PUMP OUTLET PIPE
OIL RETURN PIPE TO STRAINER IN OIL TANK
STEAM PIPE TO HIGH PRESSURE FEED WATER HEATER
OIL STRAINER
ROTARY PUMP SUPPLYING OIL RELAY
AUXILIARY OIL PUMP SUCTION PIPE
MAIN ROTARY OIL PUMP SUPPLYING BEARINGS
TO OIL COOLERS
(8467.B.)
SLUDGE DRAIN

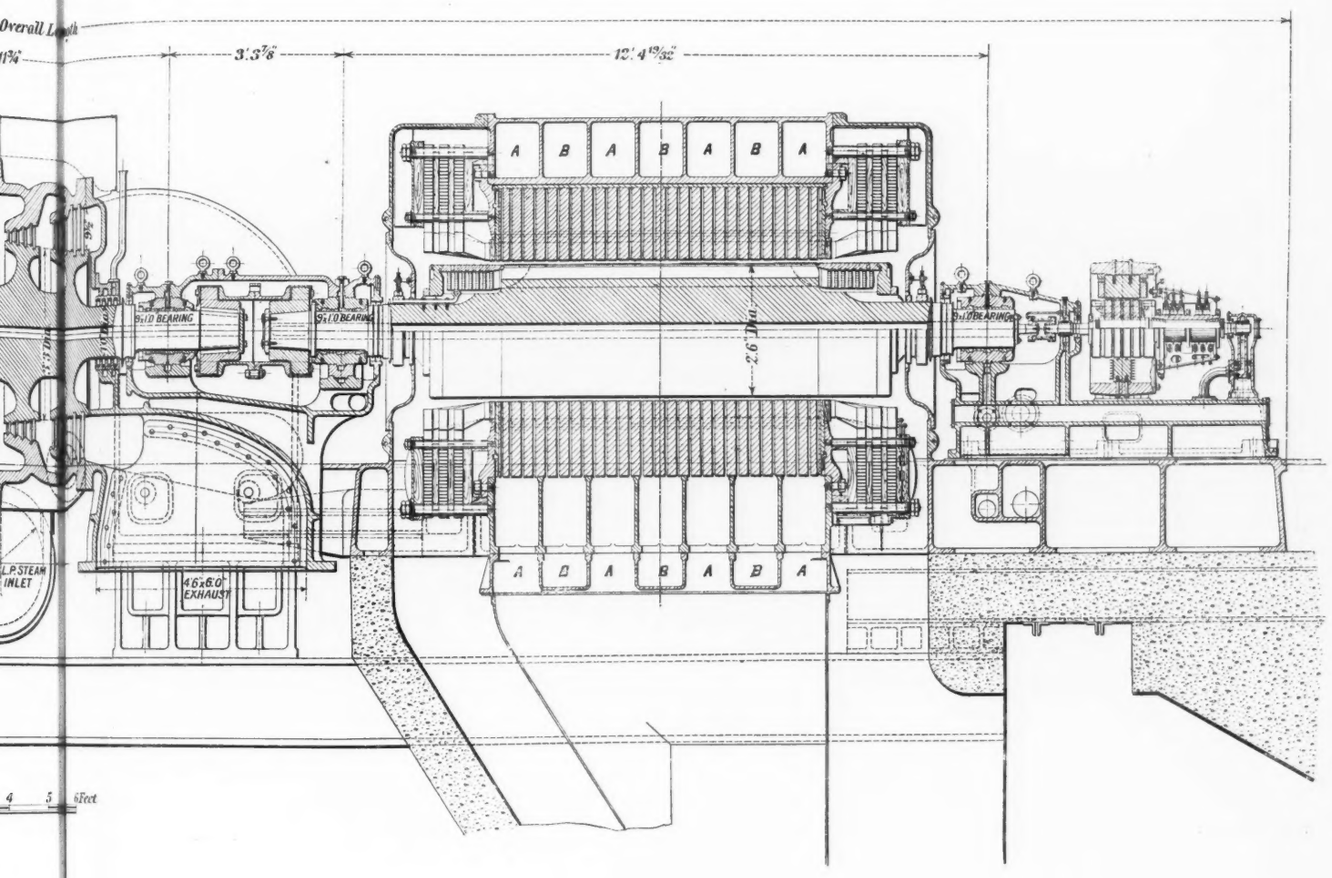
Fig. 7.
SECTION Y.Y.

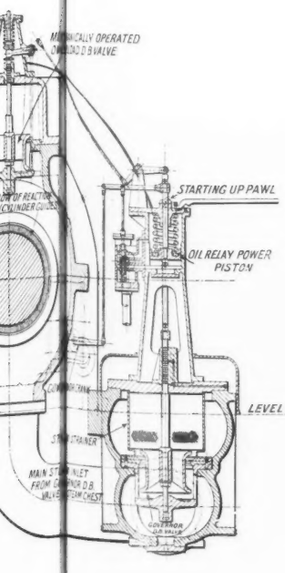


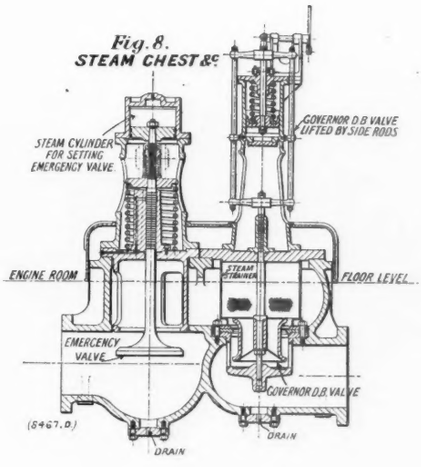
R AT THE BRITISH EMPIRE EXHIBITION.

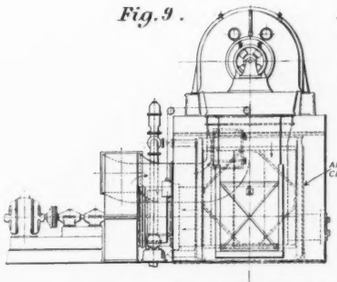
ND COMPANY, LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

scription, Page 721.)









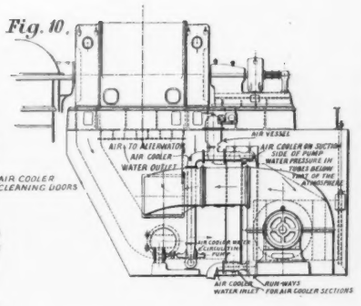
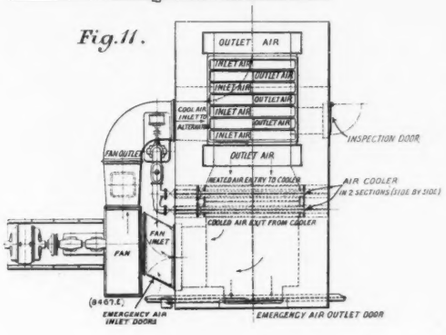


Fig. 10.
AIR VESSEL
AIR TO ALTERNATOR AIR COOLER
AIR COOLER ON SUCTION SIDE OF PUMP WATER PRESSURE IN TUBES BELOW THAT OF THE ATMOSPHERE
WATER OUTLET
AIR COOLER WATER CIRCULATING PUMP
AIR COOLER WATER INLET
RUN-WAYS FOR AIR COOLER SECTIONS



Ins. 12 6 0 2 4 6 8 10 Feet

Inches 6 0 1 2 3 4 5 6 Feet

GENERATOR AND CONDENSER FOR 12,000-KW. STEAM TURBO-GENERATOR; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. C. A. PARSONS AND COMPANY, LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 721.)

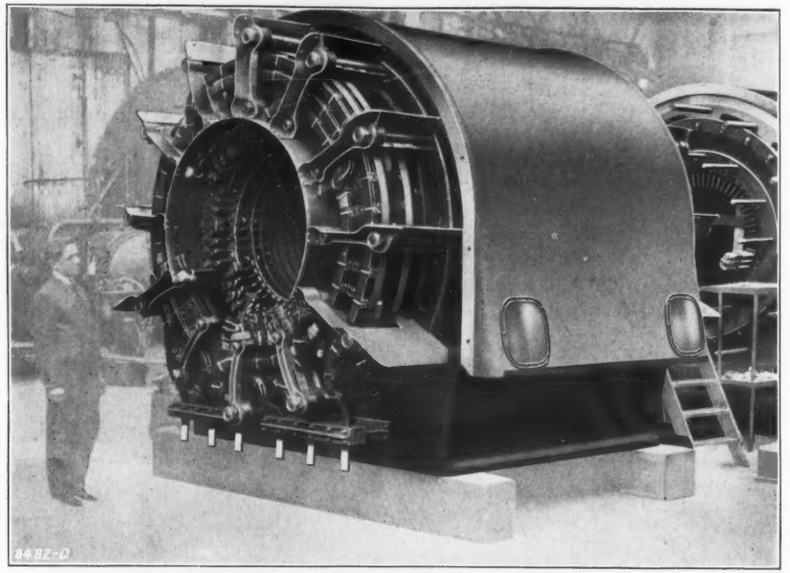


FIG. 19. STATOR OF GENERATOR.

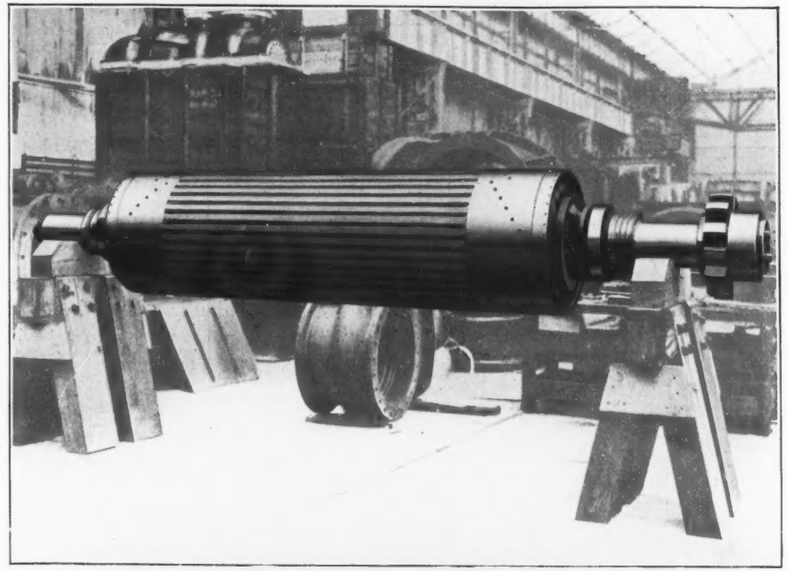


FIG. 20. ROTOR OF GENERATOR.

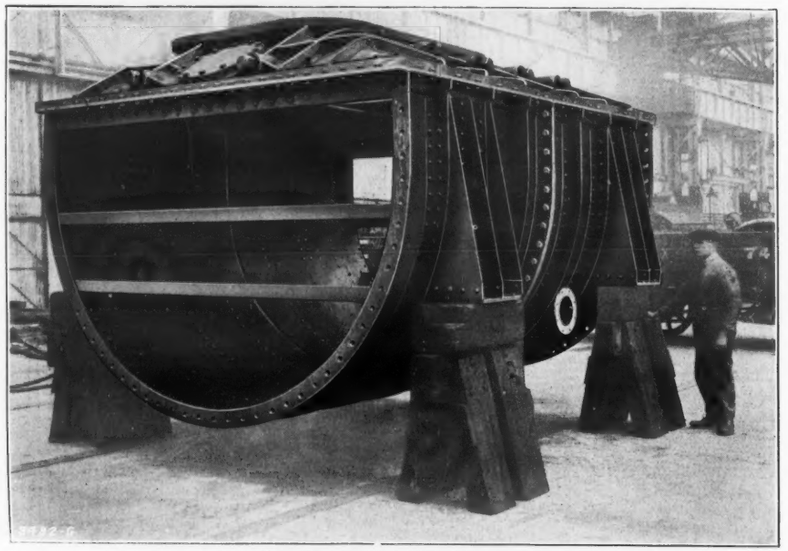


FIG. 21. CASING OF CONDENSER.

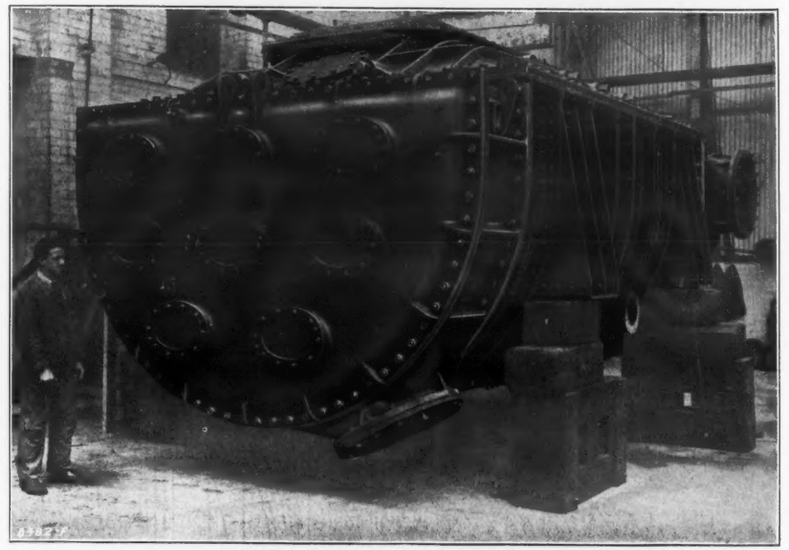


FIG. 22. SURFACE CONDENSER.

(*To face page* 723.)

blade roots and the cutting of the tenons at the blade-tips.

The attachment of the blading in both rotors of each tandem turbine is carried out on the "locked root" system (Figs. 14 and 16, page 722). In this system, heavy serrations are machined on the sides of the blade roots and these register with corresponding serrations on the sides of the grooves in the turbine. With the exception of the last two or three blades in each blade-row on the rotor, which have to be inserted through a lantern space, each blade can be placed directly in the position it has to occupy and simply twisted round by hand (see Fig. 16), so that the serrations register, after which it is driven up tight against the blades already in position in the grooves. This is possible owing to the fact that the corners *aa* of the blade roots (Fig. 16) are almost in line with the corresponding corners *bb*, so that the root can be twisted round without jamming in the groove. This makes it unnecessary to insert all the blades through the lantern space, and then drive them round into position, with consequent wear on the serrations and possible slackness. The lantern space, through which the last two or three blades in each row in the shaft are inserted, is finally closed by a serrated steel locking piece.

In the high-pressure cylinder and low-pressure shaft, the blading is "lock root" but not "integral." The blade units in these parts are made by riveting each blade to its spacing section and brazing the two together, thus forming a combined blade and section which can then be fixed in the groove on the "lock root" system. These blades, it will be seen, are integral with their roots, but are not "integral" in the sense that they are actually manufactured in one piece.

The "lock root" system is not used for the low-pressure cylinder, being replaced by "segmental" blading. This is represented in Figs. 17 and 18, page 722, one view being taken from the steam admission side and the other from the discharge side. The segments are fixed into position by means of short serrated side-locking pieces (see Fig. 18 and the left-hand side of Fig. 15), which are driven up circumferentially. The blading segments are built up by assembling individual blades and sections on a root wire, and brazing the roots into a solid mass by mechanical immersion into molten brazing alloy, the soundness of the brazing thus being made independent of the skill of the operator.

The three-phase alternators are designed for a continuous output, at 50 periods, of 12,000 kw. at 0·90 power factor (lagging) and 20,000 kw. for two minutes. The normal phase voltage at the terminals will be 6,750 volts.

A longitudinal section is given in Fig. 5, Plate LXXIII. The general construction and method of ventilation is similar to that described in detail in our issue of July 13, 1923, page 41. We may, therefore, merely state here that the stator core is supported by non-magnetic cast-iron plates and strong fingers of a non-magnetic steel alloy which are so stiff that through bolts are not required. The winding slots are completely enclosed, and the slot conductors are of helical stranded cables.

The ventilation is particularly thorough, ensuring not only a low average temperature, but also the absence of local hot spots. The air for cooling the stator enters at the ports lettered A A A A in Fig. 5, and flows along radial slots to the air gap, from which it passes into the ports B B B and thence out of the machine. Very uniform cooling is thus secured. The air circulation is arranged on the closed system (see Figs. 9, 10 and 11, Plate LXXIII), the same air being used again and again after passage through a special surface cooler. With this arrangement air filters or washers are unnecessary, and the method has now successfully passed the test of practical experience, having been in use by Messrs. Parsons since 1919. The air is drawn through the cooler by a motor-driven fan (see Fig. 11), and then forced through the alternator ducts. Arrangements are made by which the cooler can be inspected and cleaned without closing down the alternator. A view of the stator completely erected is reproduced in Fig. 19, whilst the rotor is shown in Fig. 20, on Plate LXXIV.

With regard to the surface condensing plant, twin condensers are employed for each turbine, supported on helical springs and connected flexibly to the circulating water pipes. Each condenser has an external tube surface of 9,500 sq. ft., employing ¾-in. diameter tubes. A view of the casing is given in Fig. 21, Plate LXXIV, whilst Fig. 22, on the same Plate, shows one condenser complete.

Each plant has two air pumps, arranged in parallel, and each of these air-pumps is of the two-stage vacuum augmentor type, operated by steam jets. One of them is designed to deal with one-third and the other to deal with two-thirds of the air and non-condensible gases entering the condensers. This arrangement enables economy of operating steam to be secured on partial loads. The steam from the primary nozzles of these air ejectors is condensed in intermediate jet condensers incorporated in the bodies of the apparatus, condensate from the main condensers being used as the cooling agent. The heated condensate and the condensed operating steam are passed back into the main condensers. The steam from the secondary nozzles of the air-pumps is condensed in a surface feed-water heater as already described, and the entrained air liberated.

The water supply for the alternator air coolers is taken from the main condensing plant supply conduit, but in order to prevent egress of water into the circulating air in the event of trouble being experienced with any of the tubes, the coolers are supplied with water below atmospheric pressure. In order to effect this, an auxiliary centrifugal pump is placed on the discharge side of the coolers, so that the water is drawn through them. The coolers and pumps are arranged with a considerable suction head above the supply tank in which the cooling water supply for all five plants, is maintained at a constant level by means of a valve and float. The latter admit water as required, from the main circulating water supply conduit.

It will not be possible at present to link up the Colenso Station with any existing source of electrical energy, and, consequently it will be necessary to be able to start up the station on its own power. To effect this, isolating sluice valves are fitted on the interconnecting pipes between the H.P. and L.P. cylinders of each turbine, so that any plant can be run up on atmosphere by using the H.P. cylinder alone, whilst this is being done a special steam-jet operated air ejector of large capacity will be evacuating the low-pressure cylinder and the condensers.

When current becomes available from the alternator, the electrically-driven condensing plant circulating-water pumps will be started up, together with the condensate extraction pump. Finally, the sluice valves between the turbine cylinders will be opened, the atmospheric branch closed, and the plant operated condensing.

Four of the five sets have now been despatched to South Africa, and the fifth is the one on view at Wembley.

THE COMMONWEALTH OF AUSTRALIA AT THE BRITISH EMPIRE EXHIBITION.

WE have already drawn attention to the unusual extent of the co-operation that has been shown in the British Empire Exhibition between the units, great and small, that it represents. The Australian Pavilion is a typical example of the progress that this co-operative disposition has made. For the first time in their history, the whole of the Australian States have combined with the Commonwealth Government to produce a single Australian exhibit, and the displays of individual producers are made merely as representing their respective industries. The co-ordination that has been necessary to produce this result has been the work of an Australian Exhibition Commission, under the presidency of Mr. Bruce, the Prime Minister of the Commonwealth, following on the various bodies that undertook the earlier preparations, and it includes the Prime Ministers and other representatives of each of the States. What the labour involved has been is best known to themselves, and the staff by whom it has been carried out both in Australia and under the management of Mr. H. C. Smart at Wembley. The net result has been that some 2,000 tons of exhibits were brought some 12,000 miles, and the Pavilion was among the few exhibits that were practically complete on the opening day.

Its contents show a great variety, which might have been perplexing to the visitor, but for the spacious provision that the Pavilion affords, and the admirable way in which this provision has been utilised in the lay-out. This is perhaps best shown in the lay-out plan of the Pavilion inserted in its official catalogue, and reproduced on page 724. Except for the administrative offices above the main portico and the Australian Café that crowns the exhibits of Health and Education, it is a lofty ground-floor hall some 700 ft. long by 175 ft. deep, facing the Palace of Industry on the opposite side of the lake; and with these data to locate and put a scale on it, a visitor will get a better impression of how its floor and walls are used by looking over the plan than by reading any description of the contents. Assuming, however, that a reader has taken that small trouble, and is willing to refresh his memory from time to time by referring again to the plan, it may be worth while to fill in some particulars of individual exhibits, and of what they not only are, but represent.

To understand, in fact, the real meaning of what a State shows at this Exhibition, it is necessary to have a working estimate, however rough, of the scale on which the exhibit represents its country. With the Australian exhibit this is particularly essential, because as yet the circumstances of that continent, which the exhibit is designed expressly to illustrate, are not generally recognised in this country. By superposed maps and otherwise, the authorities of the Pavilion are showing how Australia is about the same size as the United States, four-fifths the size of Canada, or over three-fourths that of Europe, including Russia, nearly three times the area of the Indian Empire, and over 25 times that of Great Britain with little more than one-eighth of its population. Such statistics, however, do not give a graphic impression of the circumstances in which the Australian exhibits have been produced. They may be indicated better by a map shaded according to the density of the population. In Great Britain, there are about 3,900 inhabitants to ten square miles. In about three-fourths of Australia there is less than one inhabitant for every eight square miles, and in about half the remainder less than one in four square miles, graduating up with smaller and smaller areas, till those that have 32 inhabitants or more to the square mile appear as scarcely more than a few spots or tiny patches of area, incalculably small in comparison with the whole territory. Even this dilute population has penetrated so thinly into the interior of the continent that, although the country is about 2,500 miles from east to west, the centre of its entire population is only some 300 miles from the south-east coast, and the centres of population in each of its great States lie from 10 to 100 miles from the coast line.

What Australia has to show, therefore, is the work of a population which in its most closely-settled districts, has not a tenth of the average density found over Great Britain, in the indefinitely larger territory that is still less settled, falls by degrees—and faster as it grows less dense—to less than half per cent. of the density of the most settled spots, and over three-fourths of the continent is less populated still. Great cities have been founded, wide-spread exploration has been made, great stores of natural resources have been discovered, and many of them are being turned to account at one place and another. Yet the relation of the extent of population to the area of territory to be settled indicates clearly that the resources of the continent are not likely to be wholly known at the present time, and what has been worked to produce the present exhibits can only be a decimal figure in a remote place of what could be had for the working. What Australia has sent is, in fact, a collection of samples, fair samples of its existing industries, but incapable of representing the extent of its resources that have still to be explored and developed; and it is with this proviso that the whole of its exhibits must be viewed.

The central position in the Pavilion is given to forestry. The timber trophy opposite the main entrance is composed of a considerable variety of

timbers, polished by Messrs. A. Pengelly and Co., of Adelaide, in their natural colours without any stain. They show a wide range of beautiful figurings, which on stand No. 6, are shown made up into furniture and parquetry, and on stands Nos. 22 and 31 into pianos (by Messrs. Beale and Co., of Melbourne) and other musical instruments. On the same stands are also shown other applications of soft woods. such as plywood, cabinet work and paper making, together with a variety of the numerous hardwoods for which Australia is famous. These include specimens that have been in service as piles, sleepers, paving blocks, and otherwise for long periods without damage—one Tasmanian peppermint tree pile has been taken out of a river after 93 years' immersion—and others that have been tested mechanically have shown high breaking strains and moduli of elasticity, in addition to densities well over that of water. They appear also in the decorative form of some remarkable carvings and inlays. A considerable number of exhibits on stand No. 31 show tan barks, essential oils, and a variety of bye-products obtained from timber distillation. A working model on stand No. 30 shows a small bush saw mill in operation. The aggregate forest area is some 120,000 square miles, much of it timbered with trees of height unusual in many other countries. This area, about a third larger than all Great Britain, is more than four times the wooded area of Norway and just on four times that of Poland. The production from it in 1921-22 is estimated at about 9,000,000*l.*

The mineral industry is represented on stands 17, 23, 24 and 27 to 29 by a large number of carefully considered exhibits, designed to show as succinctly as possible the ores, minerals and metals, the methods usual in their treatment, and their occurrence over the Continent. The chief of Australian metals is gold, and on stands 23 and 28 are shown working models of 5-head and 10-head stamps, with typical rock breaking, amalgamating, and cyaniding plant. Among a number of models dealing with complex ores and base metal mining is an interesting reproduction of the Broken Hill silver-lead-zinc lode, on which work was started 40 years ago, and has been carried three miles along the lode, sinking to various levels according to the course of the lode, the deepest being 1,815 ft. In addition to a collective trophy (stand No. 17), on which separate sections are devoted to showing specimens of the principal ores and extracted metals with particulars of their production in each State, a number of separate tropaies are displayed in the style of Fig. 4, on page 736. These exhibit, for each metal, piles of the ore resting on a base formed of ingots of the derived metal, surmounted by other ingots, with maps on the base indicating where the ores are found, and a background showing in flow-sheets the method or methods of extraction and in photographs a variety of works in which the operations are conducted. This form of exhibit, while handsome and impressive to a casual visitor, manages to convey technical information that is of real interest to mining men. Exhibits on stand 29 show in attractive forms the gems and gemstones, found in Australia, with demonstrations of methods of mining, cutting and polishing them. Other metallic ores and non-metallic minerals are shown; aluminium, antimony, arsenic, bismuth, chromium, cobalt, manganese, molybdenum, osmiridium, platinum, radium, tungsten and sulphur, coal and coke, oil shale and mineral oil, building stones, slates and pigments, clays and refractories, asbestos, corundum, limestone, magnesite, mica, rock phosphates, and others.

The mining production of Australia aggregates about 20,000,000*l.* a year, which in 1921-22 was about 6 per cent. of the total estimated Australian production in all industries; but while minerals in that year were some 15 to 20 per cent. lower than they had been ten years earlier, the total Australian production of all sorts had nearly doubled. An official enquiry into the causes of the decline in the metalliferous industries refers, among other things, to excessive cost of production and increasing charges, inadequate machinery, and insufficiently supported prospecting. This finding is more encouraging than the explanation, more common in such circumstances, that the slump is due to low prices. Many mines are run as fair weather ventures, and from bad working and imperfect equipment quite as often as from leanness of ore close down when prices fall below the top. Whether as customers for metal or designers and suppliers of plant, engineers in this country should be encouraged by the robust verdict of the Australian Committee.

Manufactures fall into a variety of distinct groups. Books and allied work, clothing and textile fabrics, furs, foodstuffs and beverages, drugs, chemicals and bye-products, soaps, perfumery and toilet requisites, spectacle cases, paints and varnishes, leather and leather goods from belting to shoes and bags, stone, clay, and glass work, furniture, bedding and upholstery, are all well represented, and for the most part are manufactures arising out of Australian raw materials. Electrical fittings and machinery and metal works and machinery include much in which a large amount of work is done in the manufactory, and from the point of view of the Australian exhibitors it is unfortunate that for the most part imperfect or no particulars have accompanied the exhibits. Occasionally this reticence and the nature of the exhibit almost suggests that the manufacturer has not been anxious to display his best work. The small exhibit, for example, of Wunderlich pressed steel ceilings is a disappointment to visitors who know the wide range of beautiful designs which this firm of Englishmen produced, while they were creating and developing the industry of steel ceilings in Australia and setting a standard for the rest of the world.

Among metal manufacturers, perhaps the best represented are agricultural implements, notably in iron and steel manufactures of the Broken Hill Proprietary Company of Broken Hill. This company operates three blast furnaces each of 450 tons capacity, and seven Siemens open-hearth basic furnaces, the ore carrying 60 to 65 per cent. of irons with limestone either from Tasmania or from Newcastle, some 100 miles away, and coke made in Semet-Solvay recuperative bye-product ovens; the annual production is 450,000 tons of pig iron, 400,000 tons of steel, 100,000 tons of wire rods, and 250,000 tons of rails, joists, angles, &c., in addition to foundry iron from a fourth blast furnace, and to iron and steel castings. Other no less significant exhibits are shown by branches or derived companies from well-known British firms, who have established works in the Commonwealth. Among these is the Australasian Scale Company, Limited, Sydney, apparently a branch of Messrs. W. and T. Avery, which shows a weighbridge and scales; Messrs. Chubbs (Australia), Limited, of Sydney, showing safes, strong room doors, &c.; and Messrs. Hadfields, Limited, manufactured steel.

The wide range of other engineering exhibits, all manufactured in Australia, shows that the manufacturing engineering industry in that country has made great strides in recent years. The evidence is not conclusive as to the volume of trade that is, as yet, done in these new undertakings, nor as to their cost; but what is quite clear is that they cover a great variety of trades, and that the quality of the products is in all instances fair and in most instances good. They extend from the manufacture of bronzes, tubes, rods and wire, die-castings, wheels, axles and tyres, and other constituents of manufacture to lathes, cutters, internal-

the exhibit of Messrs. McKay Pty., Limited, of Sunshine, near Melbourne. In Figs. 5 and 6, on page 736, two views are seen of their Suntyne drill, which at once gives a regulatable flow of seed and manure and works it in with the rear harrows. This is only one of a series of reapers, harvesters, and other farm implements which, together with oil, Diesel, benzine and petrol engines are manufactured in these works. They have a considerable sale in the Commonwealth, and among several lists that the firm issues, one giving particulars and illustrations of over 700 duplicate parts for one size of the Sunshine reaper and binder illustrates with what completeness the manufacturing arrangements provide for the convenience of customers. The State Implement Works of the Government of Western Australia exhibit a cultivator-plough and a disc cultivator outside the Pavilion, and there are other exhibits of the same class. Another exhibit, seen in Fig. 5, by Messrs. Trewhella Bros. Pty., Limited, of Trentham, Vic., is the Trewhella monkey winch, by means of which a tree may be pulled down and its roots pulled out in one process with man power, two men being able to apply a pull of 24 tons.

A notable exhibit by the South Australian Exhibition Commission shows particulars of the

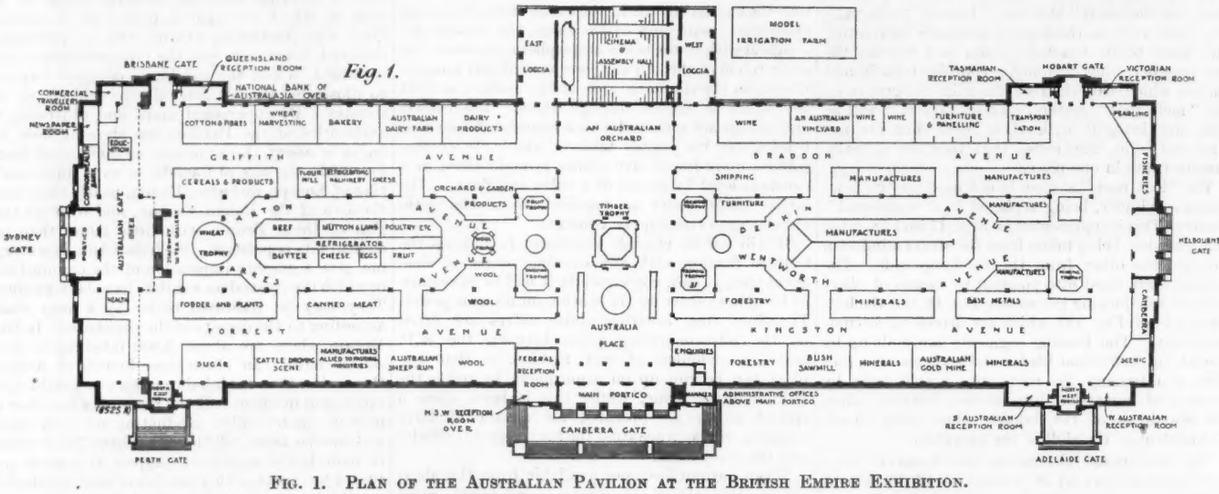


FIG. 1. PLAN OF THE AUSTRALIAN PAVILION AT THE BRITISH EMPIRE EXHIBITION.

combustion engines, hydraulic mining machinery, sewing machines and other complex finished products. The Commonwealth Small Arms Factory of Lithgow, N.S.W., shows small arms, the West Australian Government Railway Workshops wrought and cast work in steel, iron and brass, and a number of firms make electricity meters, direct-current dynamos, switch gear, and other electrical appliances.

The pastoral and agricultural industries are represented by exhibits extremely attractive to the

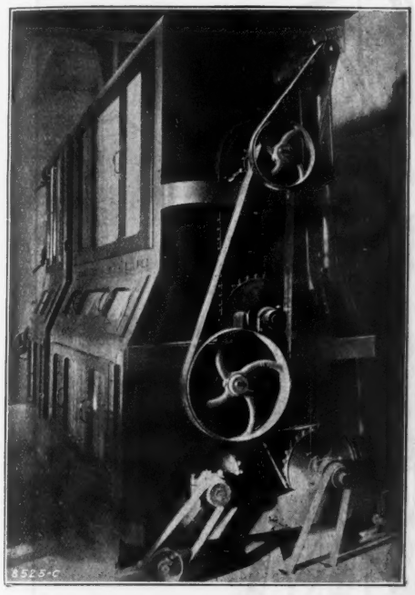


FIG. 2. "MIDGET" FLOUR-MILLING MACHINE.

general public, which show by diagrams and working models many interesting operations, and scenes involved in these classes of work. Wool, for instance, is shown not only in a very striking trophy (Stand 50), but also in the actual shearing of live sheep by a Wolseley sheep-shearing plant, put in by the Wolseley Sheep Shearing Company of Birmingham. A collection believed to be unique is shown on Stand 32 of the entire range of types of Australian wool. The meat industry is shown in a range of five refrigerated chambers each 40 ft. long by 11 ft. deep and 8 ft. high, with further chambers for eggs and cheese. The rooms are all provided with triple plate glass windows, with special arrangements that effectively prevent condensation of moisture on them; and are cooled by a combination of brine storage and direct expansion coolers, which by direct-coupled electrically-driven fans assure the circulation of dry cold air and the maintenance of a constant temperature when the plant is at rest for a considerable time. The chambers in addition to cheese and eggs contain respectively pork and poultry, mutton and lamb, butter, and fruit. They are all fitted with Cambridge and Paul thermometers connected to an indicator on the stand outside the chambers; and the fruit chamber has also a carbonic acid recorder of the same make, an illustration of the practical value that has been derived from the work of the Food Research Board on the composition of the atmosphere of fruit storage chambers, and its effect on preservation and maturity. The plant has been put in by the Lightfoot Refrigerating Company, Limited, who have provided two of their latest horizontal open-type ammonia compressors, with trunk guides and ring-lubricated bearings, one a high-speed machine running at 240 r.p.m. and the other of medium speed running at 135 r.p.m., both being driven by belt from electric motors fitted with Flexco drives. For demonstration purposes one machine is fitted with the company's special ammonia-type metallic packing and the other with cotton packing. The ammonia condenser is of the double-tube type, with special headers and joints to facilitate the removal of any pipe for cleaning, &c., when required. One of these machines is shown in Fig. 7, on page 736. The machines are exhibited as in all respects standard, and in no way differing from what are supplied in the execution of industrial work. The space is so arranged as to represent the actual arrangement of an engine room for an industrial cold storage plant.

Another industry shown in actual operation is milling, where a complete flour mill and bakery

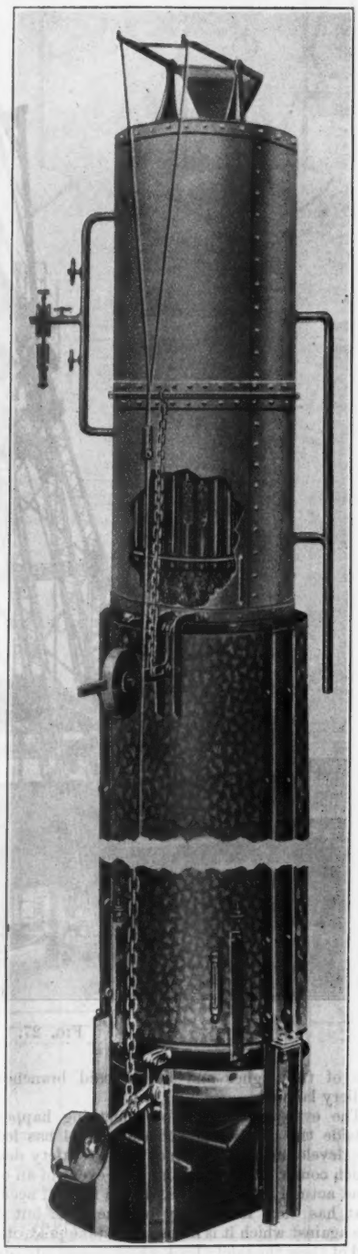


FIG. 3. "INVINCIBLE" FLOUR MOLLIFIER.

connects the scenes that illustrate wheat production and harvesting with the actual manufacture and use of the flour. For the purpose of exhibiting to the best advantage the flavour of the Australian product a "midget" mill has been provided (Fig. 2) by Messrs. A. R. Tattersall and Co., together with an "Invincible" mollifier (Fig. 3). The latter is a machine for giving wheat whatever definite degree of moisture may be desired in view of its quality and condition and of the purposes to which it is to be put, thus increasing its uniformity, strength, and ease of milling. As can be seen in the illustration, the upper part of the machine is a series of 2-in. vertical tubes, as in a tubular boiler, round which steam circulates at not more than 10 lb. per square inch, the wheat flowing through a hopper down the tubes at a rate controlled by an automatic feed bucket and discharge plate. The tubes extend 8 in. below the drums, providing a space into which vapour rising from the wheat so heated can be exhausted. The lower part of the machine is a plain cylinder, also provided with a feed bucket and discharge plate operating in unison with that on the heater; the wheat piles up and remains for the necessary time in the cylinder, which acts thus as a sort of soaking pit, and enables the wheat to be stewed to the necessary extent. It is then delivered into a cooling bin, whence an elevator takes it into the mill. The essential feature of the mill is that it cracks, separates, and gets rid of the constituent particles of the grain without working it up for a prolonged period, the operations of converting the wheat into finished flour and bran being complete within five minutes. A simple device enables the rollers to be readily and accurately set. The flour is used forthwith in a bakery plant erected by Messrs. Joseph Baker, Sons and Perkins.

An important exhibit is devoted to cotton, a relatively new crop in Australia. The fibres and a ginning plant are shown, together with cloth woven from it by English mills. The quality is said to be equal to the best on the market, and so far no sign of disease has appeared in the fields. The yield has expanded from 27,000 lb. in 1919 to about 12 million lbs. in 1923, and this extraordinarily rapid growth has led to the belief that cotton growing in Australia may ultimately be of importance comparable with wheat. The other agricultural and allied products are enumerated on the plan (Fig. 1), and their extent seems to be limited only or mainly by the extent of population available for cultivating them. In at least one instance a limit is also imposed by the markets available for sale. The wines of the country, a large variety of which is both shown in the Pavilion and sold in the restaurant attached to it, could be produced to an indefinitely larger extent if their merit were appreciated more generally; and the confidence felt in their quality leads the industry to expect a great extension as the result of the Exhibition.

A model at the back of the Pavilion shows the lay out of an irrigation farm; and indeed in respect of water Australia is served partly by its river system and direct rainfall, but also by a number of great artesian well basins that have been proved to exist below nearly half the continent. The use of water power is illustrated by a model on stand 23 of the Tasmanian Great Lake Hydro-Electric works, with a reservoir capacity of 312,500 million gallons at a height of 3,333 ft. above sea level. With pipelines running about 1¾ miles it is at present developing a maximum of 66,000 h.p., of which the Risdon Electrolytic Zinc Company of Australia takes 30,000 h.p. The current is generated at 6,600 volts and stepped up to 88,000 volts. A detailed illustrated description of these works is proceeding throughout this volume of ENGINEERING.

The Australian Commonwealth Line shows a model of a "Bay" steamer, in Sydney Harbour, and the Orient, P. & O., and Thompson (Aberdeen) lines show models of various steamers, in addition to specimens of cabins shown by the P. & O. Company. Models are also shown of railway and tramway rolling-stock, and a map of transport facilities in Australia.

The exhibits on health and education give many particulars to illustrate the high degree to which each is cultivated, and the considerable success that has been attained. The death-rate over the whole of Australia is 9·2 per 1,000, about three-fourths that of Great Britain; and although about half of three States lies within the tropics—about three-eighths of the whole continent—the dryness of the air makes the heat much less oppressive than that felt in this country during an average hot summer, and the death-rate in the tropical States is lower than in several others, all of which are well below 10 per

1,000. Art and literature are also suitably represented, and the general aim of the exhibition is illustrated by free cinema performances during the day.

Reference has already been made to some of the most important exhibits, though space does not allow of the entire collection being reviewed. What has been shown, however, seems to justify abundantly the Australian claim that theirs is a land of opportunity. Its vast extent, its British population, its beautiful climate and scenery, its indefinitely large resources, all combine to provide the conditions that give men a chance they cannot get in older and less favoured countries. The development of Australian manufactures seems at first sight to make it likely that in the future Australia will be a less valuable customer to this country than it has been in the past. It may well be that experience will not confirm this apprehension. The purpose of the Government's policy to encourage the creation and maintenance of manufactures by duties, bounties and bonuses is "to assure a maximum condition of employment." The extent to which this result will be obtained must depend on a variety of conditions besides the establishment of the industries; the extent to which they are suitable to the population, to which they supply a constant demand, to which men who work in them may undertake other work when the demand falls off. That the institution of an industry may not ensure employment can be seen from the Australian figures of unemployment for 1922, during which over 16 per cent. of workers in the engineering and metal-working industries were unemployed, as against less than two-thirds of that percentage in other manufactures.

In practice, it must undoubtedly be found that in Australia, as in this country, some industries will prove more suitable than others, and for a long time ahead the country will have a greater attraction to immigrants of the right sort in the development of its natural resources and the simpler bulk industries that flow from them than in the more complex industries to which factory life in this country is now largely devoted. The balance between primary and secondary industries will adjust itself automatically, and there can be little or no doubt that it will be such as to leave both Australia and this country willing and anxious to obtain commodities from each other in a measure that will increase constantly, beyond the limits even of the great trade that exists between them already. Each has much to offer the other. Those who seek ampler scope than is at their disposal over here will find it in Australia in favourable and congenial surroundings. Those in Australia who seek to make the most of the resources they are developing will welcome supplies from this country that give them better or cheaper means of doing the work. Each side, when the Exhibition closes, will have learnt more than they knew before it opened of the help that they can mutually exchange; and it is to be hoped that Australian visitors will take back with them an admiration of what they have seen in the products of this country and the rest of the Empire, comparable with the admiration that their own exhibit has aroused in those who have had the advantage of inspecting it.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 680).

SAFETY HOOKS.

THE winding of the cages from the pit and the stoppage at the right level differs essentially in its problems of acceleration and deceleration from the starting and stopping of a train on the level, or of a lift worked from the inside. In the case of the colliery cage, the brakesman has to take account of the inertia of the parts of his engine and of the drum, and also of the cages which do not appear in view until they are close to the surface. It will be remembered that as far back as 1801 George Stephenson became a brakesman at the Water-row pit, near Newburn, and that the work of brakesman was then considered as an art, and was one of the higher and better paid branches of colliery labour.

The ever-present risk of something happening outside the driver's immediate control has led to the development of the final form of safety device, which comes into operation in the event of an overwind actually taking place. It is a form of accident that has now fortunately become rare, but it is one against which it is necessary to take precautions, and of these the safety hook which comes into operation when the cage is overwound, securing it against falling, and retaining it in a position from which it can be safely detached, is an invention that has gone through many stages before reaching its present state of reliability.

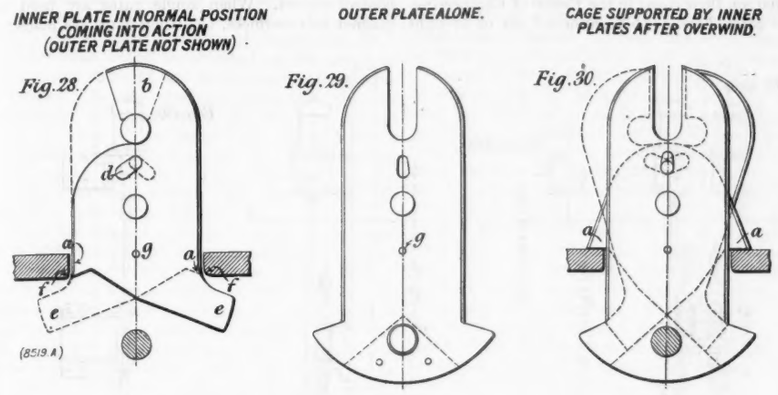
THE STEPHEN HUMBLE SAFETY HOOK.

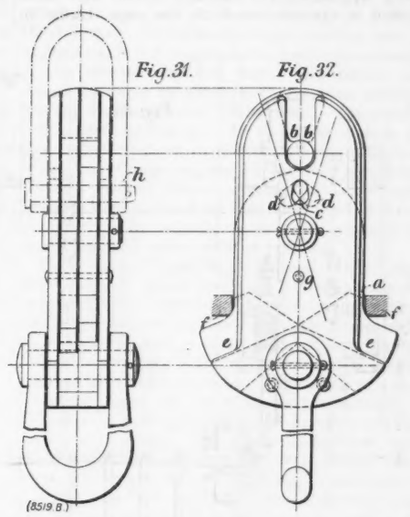
The attachment of each end of the winding rope at Wembley to its cage, as will be seen in Fig. 27, is made by a Stephen Humble safety hook. This device is shown in Figs. 28 to 32. It consists essentially of two inner plates, Fig. 28, 1¼ in. thick and two outer plates, Fig. 29, ⅞ in. thick, secured by a central pivot pin, 2 in. in diameter. The lower shackle pin 2¼ in. diameter, passes through the outer plates only, the lower part of the inner plates being cut away so as to leave a projection *a*, on each which only comes outside the upper parallel portion of the hook in the event of an overwind. At the lower part, the outer plates are secured to each other by distance pieces below the lower shackle pin; at the upper end they are slotted to clear the upper shackle pin, which is also 2¼ in. in diameter. The inner plates are formed with hooked ends *b*, embracing an arc of about 30 deg. beyond the vertical on each side; the outer edges project beyond the outer plates and are rounded to cylindrical shape so as to enter the bell or catchplate readily. Below the upper shackle pin, the outer plates are pierced with a 1¼ in. hole, slotted vertically; each of the inner plates is also pierced with a 1¼ in. hole *d*, slotted with a downward inclination on the same side as the top projecting hook *b*. At the lower end the inner plates are

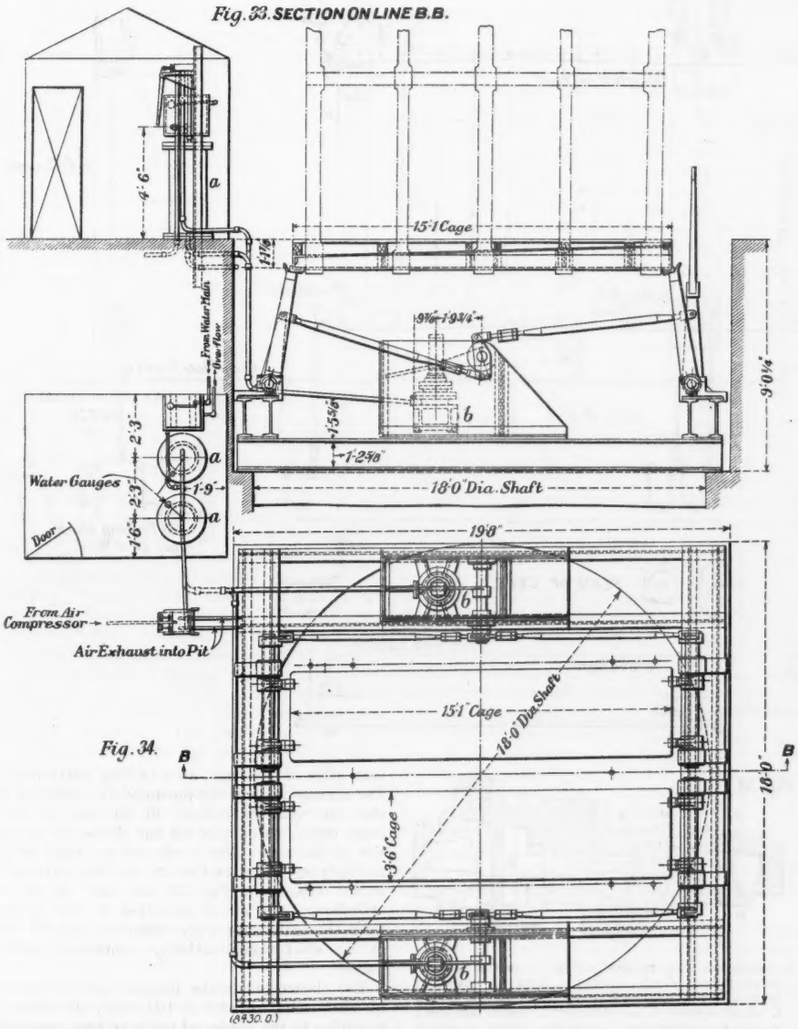
THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

FIG. 27. THE HEAD GEAR.

formed with projecting horns *e e*, on the opposite sides from *a a*, which in the event of an overwind come into contact with the underside of the catchplate at *f f*. The effect of this is to shear the safety copper rivet *g*, which under normal conditions secures the four plates to each other, and to open the hooks at the upper end, disengaging the upper shackle, Fig. 30, so that when it is completely released, the projections *a a* have come into their extreme outer positions, in which they afford a large bearing surface to rest on the catchplate. The slotted holes in the plates now occupy a different relative position, and the 1¼ in. pin of the long lowering shackle *h* (shown in place dotted in Fig. 31) can be put through this hole when the winding rope has been passed over the pulley back to the cage. As soon as the weight of the cage is taken by the lowering shackle pin, and the projections *a a* are raised clear of the catchplate, the action of lifting causes the inner plates of the safety hook to travel back to their normal position. This is effected by the inclination of the slotted holes to the tangent to a circle struck from the centre of the pivot pin, thus allowing some travel of the pin of the long lowering shackle to operate the parts of the hook that rotate about the central pivot pin. When the parts of the hook have thus been returned to their normal position, the cage can be lowered on to the keps. It is to be noted that no tools are required for the operation of freeing the cage when suspended from the catchplate. When the cage has been lowered on to the keps, a spare hook can be immediately substituted and the safety pin replaced in the hook that operated for the overwind.


INNER PLATE IN NORMAL POSITION COMING INTO ACTION (OUTER PLATE NOT SHOWN)
OUTER PLATE ALONE.
CAGE SUPPORTED BY INNER PLATES AFTER OVERWIND.
Fig. 28.
Fig. 29.
Fig. 30.
(8519 A)





MARSON'S HYDRO-PNEUMATIC KEP-OPERATING GEAR.

The kep-operating gear, which has been constructed by Messrs. Markham and Co., Limited, of Chesterfield, is illustrated in Fig. 14, Plate LXVI, of our issue of May 23, and also shown in Figs. 33 and 34, annexed, in side elevation and plan respectively. It consists of two sets of keps, one set for each cage, each set controlled by an operating cylinder filled with water and using compressed air as the motive power; the compressed air is admitted to the two cast-iron receivers *a a*, shown in Figs. 33 and 34, which are nearly filled with water, and are in direct communication with the operating cylinders *b b*. When it is desired to pull the keps out, compressed air is admitted to the one or the other of the cylinders by means of one of the slide valves provided at the banking level and operated by the hand levers. The air acting on the surface of the water in the receiver, pushes up the ram in the corresponding operating cylinder, thus withdrawing the keps. The advantage derived from the use of water as the transfer medium is that the amount of compressed air used for each operation is reduced to a minimum. Each set of two pairs of keps is, of course, operated independently, and for this reason two cylinders and double slide valves are fitted. The level of the water in the receivers is maintained by the cistern placed just above them, and double check valves prevent the water from being blown back. This type of kep gear, which is in use in a large number of collieries, has the advantage that it is not necessary to lift the cage off the keps before lowering, thus effecting a saving in power and time in the engine room. With a gear of this type, fitted in a colliery having a pit 905 yards deep, the cages weighing seven tons and lifting an average load of 4½ tons of coal carried in six tubs on double decks, the changing time amounts to about 10 seconds.

SAFETY GEAR.

The working of a colliery has many points of similarity to the working of a railway; each has to deal with the moving of large quantities of material from one point to another, and in each case speed and safety are the most important factors. The latter has been standardised and developed by railway signal engineers to so high a degree that the working of the Underground Railways of London by means of electro-pneumatic control and interlocking gear has become almost automatic. This system saves the signal operator the heavy and unnecessary manual labour formerly

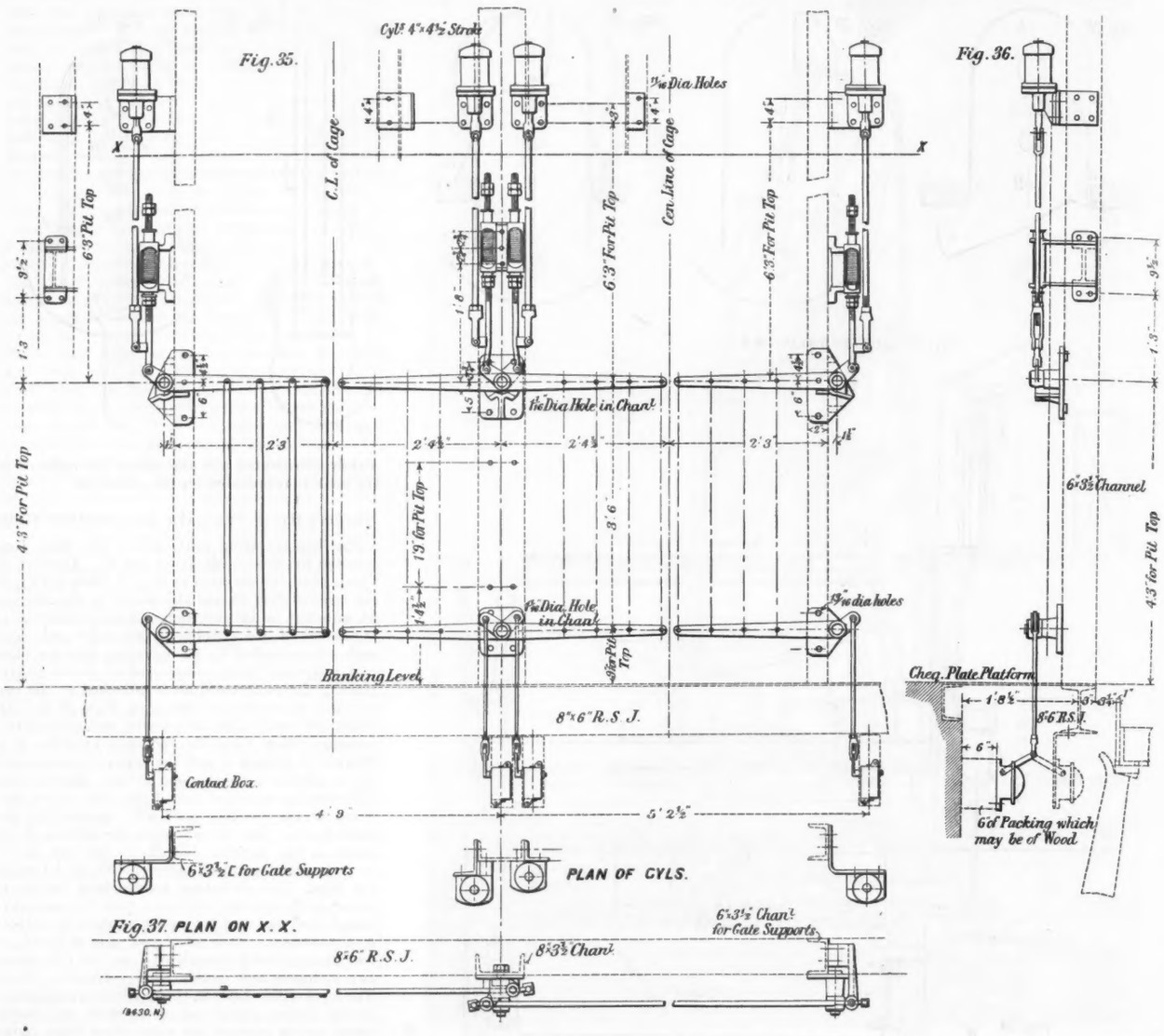
required for moving the long levers, and it enables him to give closer and better attention to the traffic. It is natural, therefore, that those who have taken a leading part in the evolution of safety appliances for railways should also have devised a system suited to the cage traffic in collieries, with controls and interlocking gear so arranged as to secure the rapid and safe handling of men and tubs with a minimum of hand labour.

Automatic Safety Gates.

It is required by the mining regulations that a pit shaft shall be closed when no cage is at bank level. This car be complied with most conveniently by an installation of power-operated gates that can be made to open automatically on the arrival of the cage at the bank, and to close immediately the cage commences to descend. The pit at Wembley is fitted with pneumatically-operated automatic gates made by the Westinghouse Brake and Saxby Signal Company, Limited, who have made a special study of a whole group of appliances devised for ensuring the sending and acknowledgment of signals as well as the interlocking of the appliances to cover the different conditions that arise in the raising and lowering of tubs and of men.

We have already mentioned that the cages at the colliery have been modified for the convenience of the public by boarding over the inclined floors. This has restricted the plant which has been fitted at the mine to the gates and gate-control gear, the rails and the appliances required in handling the tubs having been suppressed, but these are exhibited by the Westinghouse Brake and Saxby Signal Co., Limited, on their stand in the Palace of Engineering.

The gates, Figs. 35 to 37, annexed, are of wrought iron, of the folding type and of substantial construction. When the cage has come into line with its top or bottom position, the wrought-iron striker arm which it carries operates a circuit breaker and completes the circuit energising an electro-pneumatic magnet valve, and by this means power is applied, causing the gates to swing upwards clear of the tubs. They return to their normal closed position under the action of gravity and are cushioned by the spring shock absorbers immediately the air is cut off the cylinders, which occurs as soon as the cage begins to move and breaks the control circuit. When single gates are used one magnet valve suffices, but when gates are placed on both sides of the cage, an auxiliary valve is fitted. The arrangement of the pneumatic cylinders is such that one cylinder suffices, in the case of two or more decks, to operate all the doors on the same side of the cage; this is effected by duplicating or multiplying the attachments to the vertical rod, shown broken in Fig. 35, for each of the four cylinders. The air is admitted to the cylinders from the main air supply either by magnet valves or by electro-pneumatically controlled auxiliary valves.



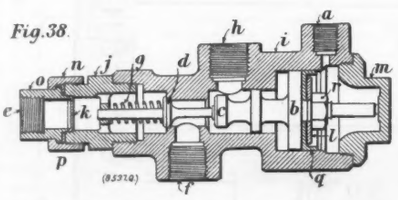


Fig. 38.

a. admission from magnet valve; *b*. piston; *c*. exhaust valve; *d*. pin valve; *e*. inlet; *f*. outlet to apparatus; *g*. spring; *h*. exhaust to air; *i*. body; *j*. union nipple; *k*. air strainer; *l*. piston follower; *m*. cap; *n*. union nut; *o*. union socket; *p*. union gasket; *q*. piston packing; *r*. piston nut.

The electro-pneumatic magnet valve is operated by alternating current at 100 volts, 50 cycles, and is similar to the valves which have been extensively used for railway signalling installations. Contact boxes are provided for proving that each half of the gates is open; in a fully-automatic decking plant this detection is necessary to prevent decking movements taking place before the gates are open, and, in the case of the installation at the colliery at Wembley, a circuit is taken through these boxes to an illuminated indicator which shows "Gates Open" when the movement has been completed. All the contact boxes are of rugged

design and are provided with water and dust-proof gasketed lids.

AUXILIARY VALVES.

The auxiliary valve of the electro-pneumatic control system, shown in section in Fig. 38, is used where a larger quantity of compressed air is required than would be obtained by the action of the magnet valve of the electro-pneumatic system of control. In such case, instead of admitting the compressed air direct to a cylinder, the magnet valve operates an auxiliary valve which forms a pneumatic relay, allowing air to pass from the main supply, through a ½-in. port direct to the apparatus to be actuated. The operation of the auxiliary valve is as follows:

When the magnet valve is energised, compressed air is admitted through the connection *a* and pushes the piston *b* to the left, seating the exhaust valve *c*, and unseating the pin valve or inlet valve *d*. So long as the valve *d* is held open, by the pressure of the air behind the piston *b*, compressed air will flow from the air supply through the inlet *e*, the valve *d* and the outlet *f* to the apparatus to be operated. When the magnet valve cuts off the air from behind the piston *b* this piston with its stem and valves, assisted by the spring *g*, will be returned to its original position and held there by the air pressure from *e* acting on the valve *d*. This movement, which has unseated the exhaust valve *c*, allows air to escape from *f* through the valve *c* and the outlet *h* to the atmosphere. The strainer *k* is fitted to prevent dirt from entering the apparatus.

(To be continued.)

THE INSTITUTE OF TRANSPORT BRISTOL CONGRESS.

THE Institute of Transport held its summer Congress this year at Bristol, on May 29-31, inclusive. A good programme was arranged, including several social events, but the reading and discussion of papers were restricted to the mornings of Thursday and Friday, the 29th and 30th. The number of papers considered was smaller than usual, but the four taken were thoroughly representative of the chief transport subjects, being devoted to ports and shipping, roads, railway operation and aerial transport.

After the welcome by the Lord Mayor of the city, two papers were taken at the morning meeting on Thursday. These were "The Port of Bristol—Past and Present," by Mr. D. Ross-Johnson, and "The Problem of Road Surfaces with regard to Mechanical Transport," by Colonel E. S. Sinnott. As will be gathered from its title, Mr. Ross-Johnson's contribution was largely of an historical nature, tracing the earlier development of the port and showing how its present trade and imports followed lines which were the natural outcome of early traffic with Spain, the West Coast of Africa, and North America. The paper resolved itself into a discussion of the old port at Bristol itself and the newer portion at Avonmouth, with reference to the oil depot at Portishead. The history of the management of the Port is in some senses unique. The city originally managed the port, but the reluctance of that body to embark upon schemes of improvement led to private enterprise constructing the floating harbour in 1803. The company did not prove successful, its powers with regard to financial matters being unsatisfactory, and the city finally bought the company out. This, however, did not cure all the troubles, as the length of time involved in coming to decisions again threw the port back when, in the seventies, steamers began to increase appreciably in size. Again private enterprise stepped in, and two opposition companies constructed docks nearer the mouth of the estuary. Subsequent competition resulted ultimately in the acquisition of the companies' docks by the Corporation, and now all are worked as one undertaking.

Mr. Ross Johnson pointed out that although the Royal Edward Dock at Avonmouth was completed in 1908, it was not till 1917 that the balance in goods handled turned in favour of the outer docks. Now 71 per cent. of the total tonnage was accommodated there and 70 per cent. of the revenue was earned by them. The port as a whole has suffered under an excessive burden for sinking fund imposed upon it by Parliament. This had recently been corrected, but for long the amount put by for sinking fund has been more than double that of a trust dock with similar capital. It had thus been necessary to draw upon the rates, but while the rate last year produced 60,000*l.*, the sum of 95,000*l.* was carried to sinking fund to replace capital, and the docks may be considered to be in a very sound financial position. A scheme of enlargement has recently been commenced at the Royal Edward Dock, which takes the form of an extension 1,700 ft. long and 400 ft. wide, in continuation of an existing quay, giving a clear length of quay of 2,800 ft. at this point. Bristol fulfils many of the ideal conditions for a port. It is within 65 miles of the open sea, and a circle of any radius drawn with Bristol as centre contains more land than practically any other port of the Kingdom. The high range of tide has saved complications. The port is in easy reach of the Midland manufacturing districts, and imports can be largely distributed by water, about one-third of the traffic being so handled.

We may say that in the Thursday afternoon programme was included a visit to the Avonmouth Docks where members had the opportunity of inspecting various features to which Mr. Ross-Johnson's paper drew attention.

The other paper taken on Thursday dealt with the road question more particularly from the rural point of view. In this paper Col. E. S. Sinnott pointed out that the bulk of the traffic was now mechanically propelled, and that as motor vehicles were taxed for the purpose of road maintenance the owners naturally demanded good roads from the start to finish of their journeys. Grants were, however, only made in respect of first and second class roads, leaving the rural districts very ill placed to deal with the remainder. Taking his own county of Gloucestershire, Col. Sinnott showed that out of a total of 3,568 miles of road in the county no less than 2,933 miles were unclassified and therefore received no grants; while of this figure 2,505 miles came under 35 borough and district councils, who in all only received grants in respect of 14 miles of first and second-class roads. It was clear from these figures that the ratepayers in the country still had to bear by far the largest portion of the annual outlay in this connection. After a brief discussion of various types of road surfaces and pointing out which were within the means of the smaller authorities, Col. Sinnott advocated that the standardisation of road surfaces should be taken up. He proposed the construction of a test track under the Ministry of Transports so that surfaces and types of construction might be definitely classified as able to bear a certain tonnage of traffic. He further advocated the abandonment of the restriction of grants to first and second class roads, and that the second class should be extended, within limits, to every highway which could show a definite proportion of motor traffic. Special grants might be made to authorities where a new type of surface beyond their means, was required. It was pointed out that in agricultural counties the owners of horse transport represented a large proportion of the ratepayers, and that now that agriculture was in anything but a flourishing state the farming community not unnaturally resented the great difficulties entailed in meeting the demands consequent upon the expansion of motor road transport.

The paper by Mr. H. R. Griffiths on Friday morning, entitled "Freight Train Formations," consisted mainly of a description of the system employed on the Great Western Railway of computing and making up freight train loads. The author showed how the engines employed were classified as to power and also as to sections they could work over and the loads taken. The different classes of traffic were classified and ready-reckoners provided showing at a glance the equivalent quantity or number of trucks of one size, of one traffic to a standard; the number of standard units taken over different sections were regulated according to engine groups. The author next proceeded to consider marshalling yards and hump working, giving some interesting conclusions reached by a committee appointed some time ago on the Great Western Railway, to inquire into the best arrangements for gravity-shunting yards. Among other points to which attention was drawn was the desirability, for the most satisfactory operation, of separate winter and summer humps, and of the use of standard wagons; the difference, for instance, in humpworking with oil or grease axle-box wagons having quite an influence of the operation of the yard. The author concluded his paper by reference to questions affecting running such as speed of "fitted" and "non-fitted" trains, break-aways, &c. He drew attention to the encouragement given by the Great Western Railway to the use of large wagons, by the offer of a rebate on fully loaded 20-ton wagons for coal traffic. Mention was made of the fact that dead end stop blocks were in suitable cases being replaced by raised banks of ashes without rails.

The paper by Colonel W. A. Bristow on the "Next Five Years of Aerial Transport" brought out the present disparity between winter and summer aerial traffic and pointed out how impossible it was under such circumstances to organise an efficient service. Either the expenses of the winter weeks were disproportionately heavy owing to the retention of a staff for which there was no work, or there would be difficulty in getting the summer services working satisfactorily again. As it was not possible to make more passengers travel in winter, some even of those offering having to be refused owing to shortness of daylight and bad weather, Colonel Bristow considered that greater attention should be paid to the development of freight. This had developed so well on the London–Brussels–Cologne route that it supplemented in a very satisfactory manner the passenger traffic procurable. Translating the freight carried into equivalent passengers, on this route, while the ratio of actual passengers in July, 1923, to those in January, 1924, was 13 : 1, the ratio of passengers and freight together for the same dates was 4 : 1 only. Started in April, the service was carrying 50 tons daily in October and refusing other traffic offering. Freight might be divided into two classes, the first being small and urgent consignments which could be used as make-weight for high-speed passenger machines; the second bulkier packages suitable for carriage by special freight machines at a speed of about 70 m.p.h. At present less than 25 per cent. of the total fully-loaded weight of a machine was paying load. That worked out to about 4 lb. per horse-power. If a saving in engine or structure of only 1 lb. per horse-power could be effected the paying load would be materially increased. Engines had been suggested involving an increased weight of as much as 1½ lb. per horse-power. Clearly that would reduce the paying load very considerably. In design Colonel Bristow considered the water-cooled engine had more nearly approached finality than the air-cooled type. He considered that attention would have to be turned to metal construction in conjunction with the cantilever type of monoplane, with some improved class of wing. There were prospects of securing in a few years a machine with a maximum load of 20 lb. per horse-power and paying load of 6½ lb. per horse-power. In connection with fuel economy, the Ricardo system of stratified charges was referred to, as well as the "Bi-fuel" system of using either petrol or petrol + alcohol, the latter constituent being added automatically by an auxiliary jet. Water introduced by an auxiliary jet in the carburettor system was also discussed.

Among the visits to works paid by members of the Congress, parties were shown over the works of the Great Western Railway at Swindon, of Messrs. Stothert and Pitt, Limited, Bath, the Bristol Aeroplane Company, Limited, Filton, the Severn Canals, and the factories of Messrs. J. S. Fry and Sons, Limited, and the Imperial Tobacco Company, Limited.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—The name and address of the newly-appointed Secretary of this Institute is Mr. W. H. Plant, "Ungava," Barr Common, Walsall, to which address all correspondence should be sent.

THE OLD CROMPTONIANS' DINNER.—An interesting dinner was given on the 31st ultimo at the Royal Automobile Club by past and present members of Messrs. Crompton, Chelmsford, to commemorate the eightieth birthday of Colonel R. E. B. Crompton, C.B., who was the guest of the evening.

METALLURGY AT THE BRITISH EMPIRE EXHIBITION.—III.

THE stand of Messrs. Hadfields, Limited, Sheffield, is placed in approximately the centre of the Palace of Engineering, and contains representative exhibits of the firm's numerous products, of cast, rolled and forged steel. We may here incidentally remark that the late Mr. Robert Hadfield was practically the first to take up, in 1869, the manufacture of steel castings on a large scale, and the firm have since well maintained their reputation in this, one of their leading specialities. In the centre of the stand is a group of four cast-steel hydraulic cylinders, placed upright, nearly 30 ft. in length, the walls being 2 in. thick only. When it is considered that in the process of manufacturing such cylinders the steel has to fall a height of about 30 ft. from the runner or head to the bottom of the mould, it would seem almost impossible to secure soundness in the casting, yet such cylinders, of which Messrs. Hadfields have supplied many thousands for cotton baling and other presses, will stand the very severe test of from 3½ to 4 tons pressure per square inch, without the slightest sign of weeping, leaking or other defects. Such cylinders, therefore, illustrate the perfection attained in the steel foundry practice of the firm much more than do heavier steel castings of comparatively simple shape. Messrs. Hadfields have acquired a world-wide renown in the manufacture of "Era" manganese steel, discovered by Sir Robert Hadfield as early as 1882; specimens are shown taken from the original iron-manganese research ingots made by him in that year, also samples of the original tools and implements manufactured at the time to ascertain the fitness of the new alloy for a number of different purposes. Since those early days, manganese steel castings have been used very extensively for heavy wearing parts of machinery of every description, such, for example, as jaw faces for crushing machines, tumblers, buckets, pins and bushes for dredgers. A large "Era" manganese steel dredger tumbler which has had a long life in every day service has been lent for display at the stand by the Port of London Authority, who state that such parts made of manganese steel last many times longer than similar pieces made of toughened ordinary cast steel. Near this are shown a complete dredger bucket, bucket lips, pins, bushes and other dredger parts, all made of the firm's manganese steel. This steel has been used for many years past for the manufacture of tramway points and crossings. A specimen of Messrs. Hadfields' "Hadura" tramway point is exhibited, together with a railway crossing built up of rolled rails of "Era" manganese steel. This important application of manganese steel was first covered by Sir Robert Hadfield's patent issued in 1903. One exhibit is a portion of an "Era" manganese steel tramway lay-out, consisting of points, crossings and other parts, which was removed from Fitzalan-square, Sheffield, after a period of about twelve years, during which time, as stated by the tramway engineer of the Corporation of that City, thirteen and a-half million tramway cars had passed over it, equivalent to an aggregate of about 137,000,000 tons of traffic. The railway and tramway exhibits further include tramway wheels, axles of various types, railway wheel centres and locomotive castings and tyres. The firm's specialities for collieries include wheels and axles fitted by the Hadfield patent lock-fast method, pulleys and frames, rollers and frames, pedestals, self-oiling wheels and axles, &c. Show cases contain a variety of specimens for motor-cars, commercial vehicles and aircraft. There are, further, numerous specimens made of the firm's "Galahad" non-rusting steel, "Era A.T.V." heat-resisting steel, low hysteresis and other steels. Messrs. Hadfields' activities during the war are illustrated by a series of their "Heclon" armour-piercing and other projectiles, a 6-in. trench howitzer, a fired 4-in. armour plate, a 6-in. gun shield cast of "Era" steel, which is stated to have withstood a total striking energy of 8,950 feet-tons on an area of impact of only 13 sq. ft.; also tested soldiers' helmets and body shields of "Resista" steel. Messrs. Hadfields have cast medallions of "Era" manganese steel; the remarkable smoothness and good finish of these illustrate the very high proficiency which they have reached in foundry practice, specially considering the high temperature at which this particular steel has to be dealt with, namely about 1600 deg. C. These medallions and what we may term the purely metallurgical exhibits above referred to, also afford a proof of the excellent work carried out in the firm's research laboratories.

Messrs. Hadfields' specialities in crushing machine work are illustrated by their "Hecla" disc crusher, of which they are the sole makers under the Symons patents. The material fed to the machine is contained within the hollow formed by two discs set with their concave sides facing each other. The discs rotate in the same direction at the same speed, and being set at an angle there is a wider opening between the edges of the discs at one part of their circumference than at the opposite part. The stone is thrown to the opening where the discs are widest apart, it then goes round to where they are closer, being crushed in the process. The "Hecla" disc crusher is noted for the cleanness, uniformity and cubical nature of the sample it produces, thus providing an excellent top-dressing for roads. It has a very large capacity in medium coarse crushing. The discs are of "Era" manganese steel. As an example of working, it may be stated that the 24-in. disc crusher takes fed pieces up to 5 in. by 4 in. by 2½ in., crushing these at the rate of 15 tons to 20 tons per hour, according to the quality of the material and the fineness of the product. It is a useful machine for converting waste material into usable sizes.

The firm's patent jawbreaker embodies the double toggle principle and is made in sizes ranging from a mouth opening as small as 10 in. by 6 in., up to machines having a receiving hopper 84 in. by 60 in. The particular breaker in the exhibit is their standard size, 12 in. by 8 in., which, like the others in the series, is of cast-steel construction. It is now firmly established that cast-steel breakers, despite their relative lightness as compared with those made of cast iron, are much better suited than the latter to the heavy duties associated with crushing operations, whilst their lesser weight minimises freight and up-country charges in the case of machines for service abroad. All the wearing parts of the breakers are of "Era" manganese steel. Messrs. Hadfields' jawbreakers are made with sectional or solid frames, also of the single toggle type, if desired, and can be arranged as granulators for producing a moderately fine sample.

The Caledonian Wire Rope Company, Limited, Airdrie, Scotland, show a large collection of specimens of their steel wire ropes for marine, mining, agricultural and all engineering purposes. They include winding and haulage ropes, non-rotating sinking ropes, galvanised flexible winch ropes, flexible coal-cutter ropes, ropes for aerial ropeways, ropes for power transmission, flexible ropes for lifting machinery, steam ploughing ropes, flexible dredger ropes, &c. Three specimens of the company's manufacture of former years are exhibited also. These are a sample of wire rope supplied by them to the London County Council and which worked from 1899 to 1912, when it was removed because of age, worn but otherwise undamaged; a sample from the South Africa Premier Diamond Mine, 1⅝ in. diameter, supplied in a length of 7,000 ft., said to have hauled a total of 1,120,000 tons and to be still in serviceable condition; also a sample of a hauling rope supplied to the Crown Mines of South Africa, which is claimed to have performed 7,130 million foot tons of work and to have had a life of over three years. On the stand is a working model of the firm's improved "Blondin" or single-span ropeway. This consists of two terminal towers or masts, generally of lattice work, which can be placed up to 1,200 or 1,500 ft. apart, a steel wire rope being stretched at the top of the masts across the intervening space and anchored in the rear of each terminal. A carriage is suspended on this rope, and its horizontal movement is governed by an endless rope underneath the carrying rope. The carriage is provided with a lifting rope and snatch-block, for raising and lowering loads at any point within the range of the ropeway. The machinery comprises a winding drum for the lifting rope, combined with a power pulley for the endless haulage rope. They are worked together when the load is being transported; by means of a clutch the winding drum can be worked separately, to raise and lower the load as required. All the actions are under the control of one man. Loads can be worked vertically at a speed up to 350 ft. per minute, and horizontally at a speed up to 700 ft. per minute. Numbers of these ropeways have been supplied by the company to slate and other quarries throughout the country.

Messrs. George Cradock and Company, Limited, Wakefield, whose wire rope works and products we described in detail in our issue of May 13, 1921, show on their stand over 300 samples illustrating their various types of steel wire ropes. These include Lang's Lay; "Nuflex" non-rotating locked-coil, shaft guides and rubbing ropes; spiral standing ropes; oil-well ropes; logging ropes; ropes for cranes and elevators, &c., most of which, together with the processes of manufacture from start to finish, we dealt with in our article above referred to. Messrs. Cradock's display is a highly decorative one, and forms evidence of the firm's experience and activity in wire rope making for all uses. It contains also all types of fittings and attachments for use with wire ropes, samples of all classes of aeroplane cords and strands and aircraft fittings; specimens of carbon and alloy steels; also illustrations of typical cableways and suspension bridges erected by them. They show besides a selection of Oldham's mining lamps.

Messrs. John and Edwin Wright, Limited, Universe Rope Works, Birmingham, have supplied the guide ropes and rubbing ropes used in the colliery at the exhibition, a description of which is now appearing in our columns. Their display of mining ropes is a very comprehensive one. Their stand in the Palace of Engineering includes specimens of their locked-coil winding ropes, a type of rope which has practically no elongation and is absolutely non-rotating, the smooth outer surface reducing frictional wear and increasing the life of the drums and pulleys. Other samples are those of their "Keystone" strand winding rope; concentric flattened-strand winding rope made entirely of steel; Wrights' "Keystone" strand haulage rope, in which the wear is distributed over a number of wires instead of being concentrated on the crown wires only, the wedge-shaped strands also offering increased resistance to the crushing action on the drum and to the buffetings incidental to the life of a haulage rope. Specimens are also exhibited of Wrights' locked-coil guide ropes, having a completely smooth surface, as a consequence of which the wear on the rope and cage shoes is reduced to a minimum. Other items are Wrights' round-strand flexible ropes, steam ploughing ropes, high grade ropes for logging, dredger and salvage work, steel wire and Manila oil-well drilling cables, marine ropes, etc.

The special feature of the exhibit of Messrs. Thos. and Wm. Smith, Limited, wire rope manufacturers, Newcastle-on-Tyne, is a working model of an oil derrick, close to which are displays of coils of oil-well steel ropes, including drilling lines, casing lines, sand and baling lines, which are among the specialities of the firm. Among the specimens is a short length of a steel aerial cable, 9½ in. in circumference, having a breaking strength of 344 tons, manufactured by Messrs. Smith for the construction of the King Edward bridge at Newcastle. It formed an aerial ropeway across the Tyne having a span of 1,530 ft. When the bridge was completed the cable was taken down, and it has been used since in the launching of the heaviest ships built on the Tyne. Other specimens are various types of mining ropes, ropes for ships and all engineering purposes, aeroplane ropes, &c. Messrs. Smith also construct aerial ropeways complete. They issue a description of their products in the Spanish language.

SCIENCE AT THE BRITISH EMPIRE EXHIBITION: ERRATUM.—We regret that in an article bearing the above title which appeared on page 692 of our last issue, we stated in error that the Metallurgy Department of the National Physical Laboratory were exhibiting machines for testing chains, &c., in the Palace of Engineering. Actually the machines referred to in the opening paragraph of the article were exhibited by the Engineering Department of the Laboratory. The Metallurgy Department and the Engineering Department are, of course, separate divisions of the Laboratory, each having its own superintendent and staff.

THE FRASER AND CHALMERS HEAVY OIL ENGINE.

WHEN, some time ago, the General Electric Company decided to start the manufacture of heavy oil engines they realised that any apparent temporary benefit to be gained by acquiring a license to build a type already established, had to be considered in relation to the drawbacks of necessarily following behind the practice of some other firm. By developing a design of their own they saw the opportunity of improving upon existing practice with regard to many details and of producing an engine, not only free from antiquated features but one which would be exclusively associated with the name and reputation of the Company. The design of the new engine was undertaken by Mr. B. Pochobradsky, the Chief Engineer of the Fraser and Chalmers Engineering Works of the General Electric Company at Erith, who is well-known in connection with the design of the large steam turbines and turbo-blowers built at those works. A totally enclosed, forced lubrication, vertical engine working on the four-stroke cycle with compressed air injection was decided on as the most suitable type to be developed for the purposes the Company had in view, and the first of such engines to be built is illustrated in Figs. 1 and 2, above and on page 732. The former illustration shows it coupled to a Froude dynamometer for purposes of testing, and the latter gives a section which will enable the chief features of the design to be understood.

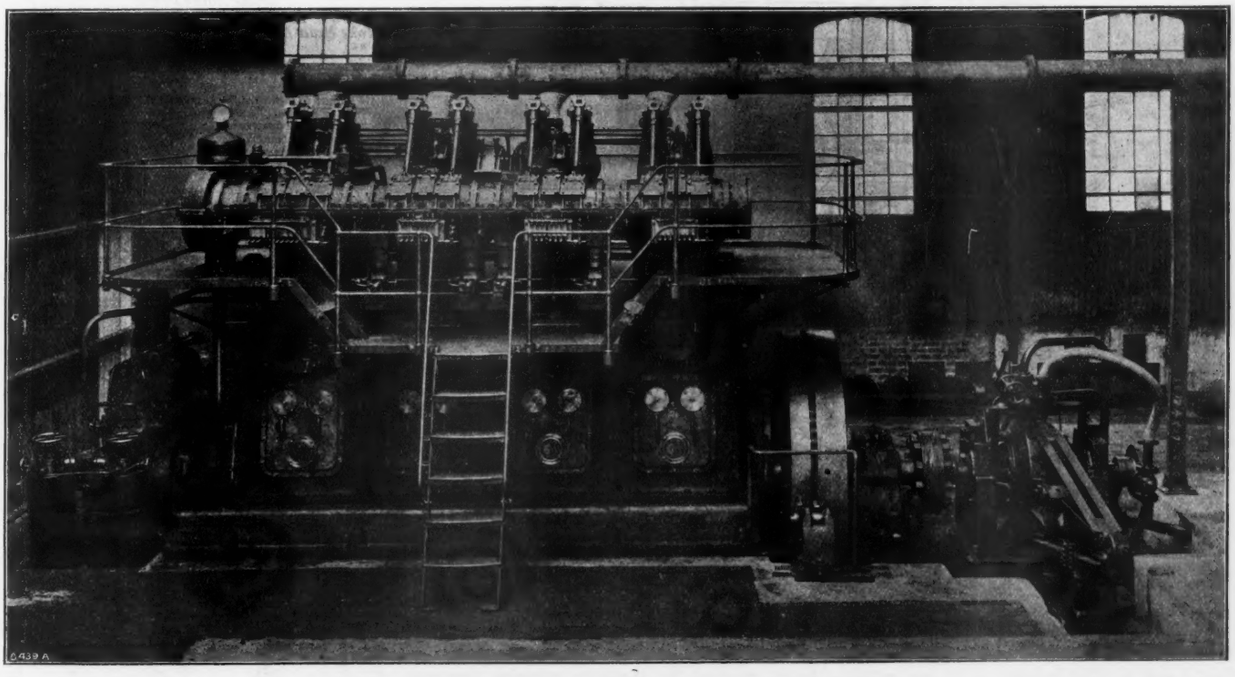


FIG. 1.

The engine has four cylinders 21·5 in. diam. by 22 in. stroke, and develops normally 1,000 brake horse-power at 300 revolutions per minute. Being the first of its kind it has been subjected to the most exhaustive tests, and its behaviour has in all respects met the anticipations of the makers. We understand that throughout the whole period of the experiments there was no trouble of any kind with the piston, cylinder or cylinder cover, and on subsequent dismantling of the engine no signs of distortion or damage could be detected. The engine is now installed in the Power Station of the Macclesfield Electric Light and Power Company driving a 750 kw. generator. In order to obtain independent and authoritative information as to its performance, the makers engaged Professor W. H. Watkinson of Liverpool University to make a complete series of tests of the engine at Macclesfield, and we shall refer later to his report after having directed attention to the principal features of the design.

No part of a heavy oil engine requires more careful consideration than the combustion chamber which has to withstand severe stresses arising from the conditions of pressure and temperature to which it is subjected. Of these two, the heat stresses are admittedly the more important, and in the Fraser and Chalmers engine they have beeen minimised by a distinct departure from ordinary design in respect of the piston, cylinder, and cover. Reference to Fig. 2 will show that each of these items has been made in two parts, a light part which is subjected on one side to the action of the gases and on the other to the cooling water, and a heavier part which is in contact with nothing hotter than the cooling water or the crank-chamber temperature. For purposes of reference, the light part may conveniently be called the hot member and the other the strength member. The separation of thermal and mechanical functions enables each member to be designed with regard only to its specific duties, which are thus carried out more efficiently than when both temperature and mechanical stresses have to be withstood by a single piece of metal. The hot members, of course, have to bear certain mechanical stresses but their primary duty is to protect the strength members, which are necessarily thick, from the extreme temperature gradients that cause trouble in thick bodies of metal.

The hot members have been designed on the principle that they must be of quite moderate and, as far as possible, of uniform thickness, that they must be of simple shape and must be cooled uniformly. The attainment of such conditions results in low and uniform heat stresses and consequently the avoidance of distortion. A liner made on this principle would be a thin hollow cylinder without ribs, as the latter would cause an irregularity of heat flow, while the importance of uniform cooling is obvious. Such mechanical forces as would cause high stresses in the hot members are not taken up by these members alone but by the strength members as well. The hot members may be regarded as interposed between the forces and the strength members to shield the latter from temperature stresses. To get the respective parts to perform their proper functions it is clearly necessary to make provision for the differences of expansion between the hot members and the strength members. The hot members will obviously expand more and this extra expansion must be able to take place freely, otherwise the hot member being mechanically weaker will soon be destroyed.

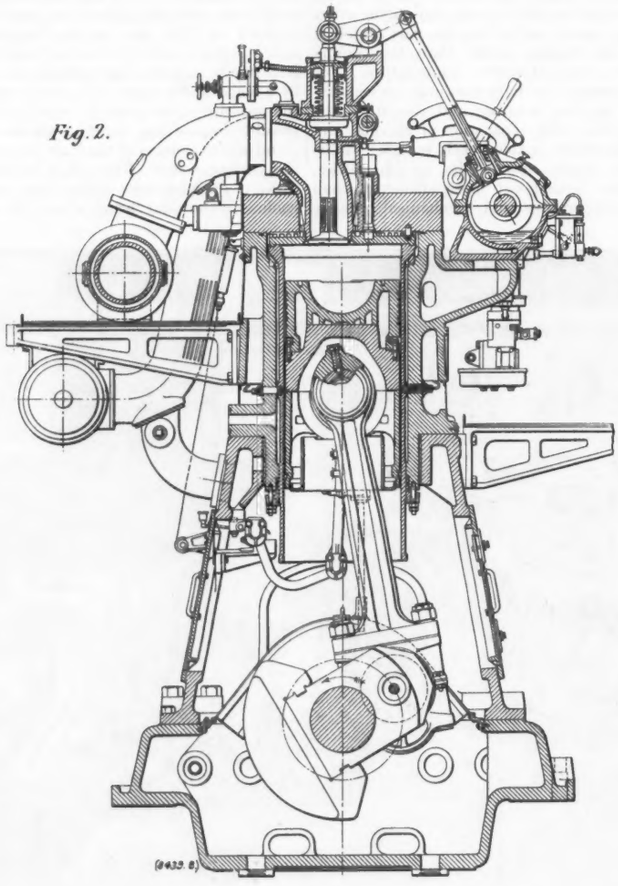
The design of the cylinder cover, as seen in Fig. 2, illustrates the application of the principles referred to. The hot member is a thin flat plate, which is not rigidly attached to the strength members either of the cover or the cylinder. It is spigotted to the thin cylinder liner at a point where the temperature of each is about the same, and the connection therefore will not alter nor be subject to stresses on account of unequal expansion. Both the liner and the coverplate are of steel, as this material has shown itself to be decidedly superior to cast-iron for parts exposed to high and varying temperatures. The liner is a plain hollow cylinder of uniform thickness. It is free to expand longitudinally as it is held only by a collar at its upper end, and in such a way that the pressure of the cover by which it is held cannot possibly impose any bending stresses upon it. A gland at the bottom of the liner prevents leakage of the cooling water. The collar is perforated by a series of diagonal holes which form passages for the cooling water and bring about the desired temperature-gradient. The cooling water is introduced between the liner and the cylinder near the lower end of the annular space and flows upwards through the holes referred to, being then guided to the cooling space between the cover plate and the cover itself. The cover-plate is a simple plate of steel and being made thin in order to minimise heat stresses, it is backed by a distance piece which both supports it against the explosion pressure and forms a guide for the cooling water. After cooling the cover-plate the water is taken round the exhaust valve casing, and thence is led away from the engine.

The piston is made of special aluminium alloy, and is in three parts. The head is detachable from the remainder of the piston. It is of moderate thickness so as to eliminate excessive heat stresses and is effectively supported by the main body of the piston to which the pressure of the charge is tranmitted. Below the head of the piston is a space in which cooling-oil circulates and thus relieves the main body of the piston and the gudgeon pin bearings from the heat which would otherwise reach them. The aluminium alloy was chosen for the head for two reasons—firstly, because it works well in contact with the steel liner and, secondly, because its lightness is valuable in reducing the weight of

the reciprocating parts, which is a consideration in view of the high speed of revolution adopted. The cooling oil is led to the piston through tubular links of bronze and steel. The links are of the rocking type, the elbows being fitted with ball bearings; special provision is made to prevent leakage without the use of packed glands. The cooling oil supply is independent of the oil supply for the lubrication of the bearings.

So far as the general design of the engine is concerned, this will be understood by reference to removing a pin in the fork-end of the push rod. The fuel valves are similarly operated by horizontal push-bars. The fuel valve needle is of tool steel and the adjustment for clearance is exterior to the valve and accessible. No special pulveriser is used and therefore no cleaning of the interior of the fuel valve casing is necessary. Pulverisation is carried out by a special nozzle which is also a substitute for a flame-plate. The starting valve is operated by air from a cam-controlled valve. A relief valve is combined with the starting valve, a large area

Fig. 2.



Figs. 1 and 2. The bedplate is in one complete casting. An oil sump and settling tank bolted to one end serves as a base for the quadruple Reavell air-compressor supplying the injection air. The tank also carries the main forced lubrication oil pump and the necessary oil service fittings. The crankshaft is machined all over, the crankpins and journals being finished to size by grinding. All crank webs are balanced. The main bearings consist of cast-iron shells lined with white metal. Lubrication oil under pressure is conveyed to the bearing housings, thence through channels in the white metal to passages in the crankshaft for feeding the big ends of connecting rods and the gudgeon pin bearings. The connecting rods are of H-section with adjustable cast steel shells lined with white metal to take the crankpins. The gudgeon pins are oil-cooled. They are hardened and are shrunk into the connecting-rod ends. They work in long bearings housed in the trunk pistons, the latter thus being free from the stresses caused by the practice, sometimes adopted, of driving the gudgeon pins into them.

All valves are readily accessible, and each can be withdrawn without disturbing its neighbours. The air and exhaust valves are operated by push rods acting upon small levers which depress the valves, the lever fulcrums being cast steel guide-brackets. The construction lends itself to the easy withdrawal of the complete valve by simply being provided for instantly releasing abnormal pressures.

The crank case, like the bedplate is a single casting, with large inspection doors giving access to the bearings and cooling gear. A separate inspection chamber is attached to the outside of the crank-case for the examination of all the piston cooling outlets. The pump for the forced lubrication system is driven from the underside of the vertical shaft. This pump is always below the oil level of the sump and therefore never needs priming. The feed pumps supplying the piston cooling oil are separate and are electrically driven. The oil coolers, both in the piston cooling system and the forced lubricating system, are of the tubular type with cast-iron bodies. A separate hand pump is fitted for charging all bearings with oil under pressure before starting up. Arrangements are made so that in the event of the failure either of the piston cooling oil, the lubricating oil, or the cooling water, the engine is automatically brought to rest at once.

The 750-kw. engine illustrated was tested by the purchasers, the Macclesfield Electric Light and Power Company, in October of last year, and the results are given in Table I in the next column. The fuel was Anglo-American Diesel fuel oil.

It will be noted that from three-quarter to full load the fuel consumption was less than 0·4 lb. per brake horse-power hour, which is a highly satisfactory result. To gain further information regarding the performance of the engine Professor W. H. Watkinson, of Liverpool University, was asked to make a full series of tests, in which every precaution was taken to ensure accuracy.

TABLE I.

Load.	B.H.P.	Lb. Oil per B.H.P. hour.
Quarter load	281	0·51
Half load	563	0·426
Three-quarter load ...	844	0·397
Full load	1,125	0·394
10 per cent. over load ...	1,237	0·415

Fig. 3.

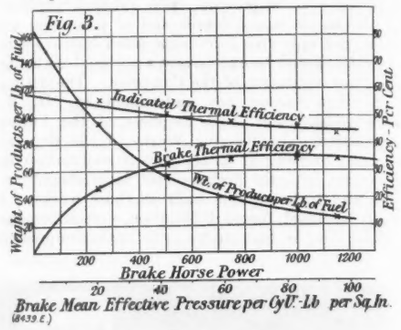

Indicated Thermal Efficiency
Brake Thermal Efficiency
Wt. of Product per Lb of Fuel
Weight of Products per Lb of Fuel
Efficiency - Per Cent.
Brake Horse Power
Brake Mean Effective Pressure per Cyl'. Lb per Sq.In.
(8439.C.)

Fig. 4.

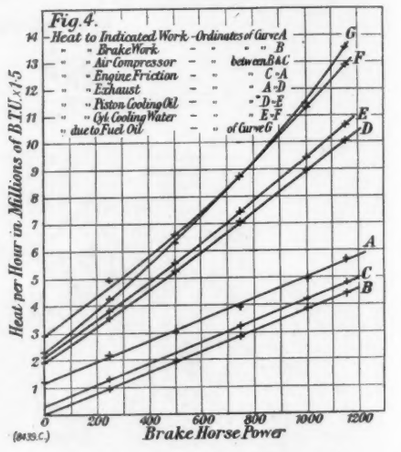
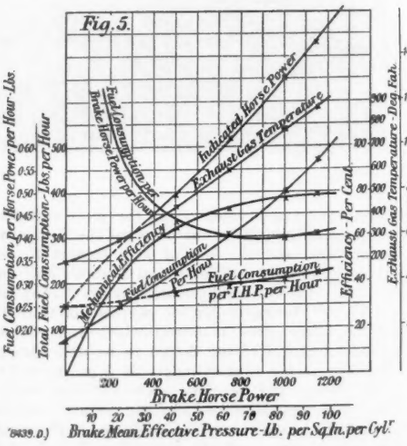

Heat to Indicated Work - Ordinates of Curve A
" Brake Work - " " B
" Air Compressor - between B & C
" Engine Friction - " C - A
" Exhaust - " A - D
" Piston Cooling Oil - " D - E
" Cyl. Cooling Water - " E - F
" due to Fuel Oil - " of Curve G
Heat per Hour in Millions of B.T.U. ×·5
Brake Horse Power
(8439.C.)

Fig. 5.


Fuel Consumption per Horse Power per Hour - Lbs.
Total Fuel Consumption - Lbs. per Hour
Brake Horse Power per Hour
Fuel Consumption per Hour
Indicated Horse Power
Exhaust Gas Temperature
Mechanical Efficiency
Fuel Consumption per I.H.P. per Hour
Efficiency - Per Cent.
Exhaust Gas Temperature - Deg. Fah.
I.H.P.
Brake Horse Power
Brake Mean Effective Pressure - Lb. per Sq.In. per Cyl'.
(8439.D.)

On the day preceding the commencement of the quantitative tests the engine was run for some hours, during which adjustments of the measuring instruments were made. During the tests the fuel oil was weighed, the weighing machine being afterwards tested and found to be correct. The brake load was applied by a Heenan and Froude dynamometer, the accuracy of which was also checked. The indicator springs and all thermometers used were tested in Professor Watkinson's laboratory, and the observed data adjusted in accordance with the corrections found necessary. The fuel oil used was sampled during the tests. It had a specific gravity of 0·890 at 59 deg. F., a flash-point (closed) of

172 deg. F., a higher calorific value of 19,120 B.Th.U. and a lower calorific value of 17,960 B.Th.U. per pound.

Six quantitative tests were made, concerning which we take the following facts and figures from Professor Watkinson's report :—

Samples of the products of combustion were taken during the tests and analysed. From the averages of these results and from the percentage composition of the oil, which contained 82·96 per cent. of carbon and 11·87 per cent. of hydrogen, and, therefore,

TABLE II.

Test No.	Per cent. O_2.	Per cent. N_2.	Air used. / Air required.	Weight of air used per lb. of oil.
				Lbs.
1	12·7	82·2	2·42	33·3
2	13·8	81·2	2·82	38·8
3	16·0	80·7	4·06	55·9
4	18·0	80·1	6·79	93·4
5	17·5	80·0	5·92	81·5
6	11·65	81·69	2·18	30·0
7	9·39	82·2	1·77	24·3

Fig. 6.

Quarter Load
Spring 1/500
M.E.P. 59 Lbs. per Sq. Inch

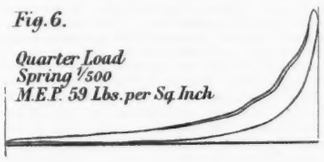
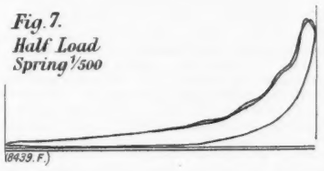


Fig. 7.

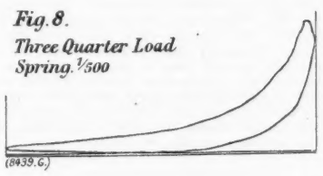
Half Load
Spring 1/500



(8439.F.)

Fig. 8.

Three Quarter Load
Spring 1/500



(8439.G.)

Fig. 9.

Normal Full Load
Spring 1/500

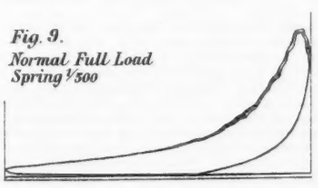
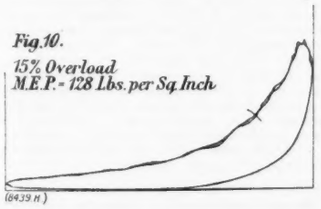


Fig. 10.

15% Overload
M.E.P. = 128 Lbs. per Sq. Inch



(8439.H.)

required 13·75 lb. of air per pound of oil, the weight of the exhaust gases per pound of fuel oil has been calculated, and the results are given in Table II.

The results for test No. 1 are unreliable because of the faulty method adopted for collecting the samples of gases during this test. The weight of air used per pound of oil, as given, includes the injection air.

The exhaust gases were absolutely invisible at all loads exception at quarter load and no load. At these loads the gases were visible as a white mist. Calculations show that at quarter load the dew point of the products of combustion was about 64 deg. F., and as the atmospheric temperature during this test was 50 deg. F., and the total length of the exhaust pipe before and after the silencer was great, it is probable that a portion of the gases during this test was cooled in the exhaust pipe to a temperature below the dew point, and this would account for a part of the observed mist.

The particulars in Table III were obtained or calculated from the indicator diagrams taken during test No. 6, full load.

The consumption of oil per horse-power hour and the thermal efficiencies, given later, show that the engine gave exceptionally good results.

TABLE III.

——	Cylinder Number. 1	2	3	4
Pressure at the end of compression lb. per square inch gauge	457	468	457	460
Maximum pressure ; lb. per square inch gauge	565	550	574	546
Value of n in equation to the compression curve	1·503	1·60	1·638	1·59
Value of n in equation to the expansion curve	1·242	1·216	1·242	1·223
Indicated M.E.P.	113·2	99·9	121·3	96·3

The work done against the friction of the pistons is converted into heat and a portion of this heat is given to the cooling water and cooling oil.

With regard to the amount of lubricating oil used, the following approximate results were obtained. These results give a figure which is somewhat higher than would be anticipated after the engine has been in service and more lubricating oil was used because of the newness of the engine :—

	Gallons.
Oil per hour for the engine pistons ...	0·42
Oil per hour for the air compressor ...	0·11

It is estimated that the oil consumption will not be more than 1 per cent. of the fuel consumption.

During the whole of the tests Professor Watkinson reported that the engine ran smoothly and without a hitch of any kind, and it was remarkably free

TABLE IV.

——	B.Th.U.	Per cent.
Heat due to fuel oil used per hour ..	$7·166 \times 10^6$	100·00
Heat to indicated work per hour ..	$3·324 \times 10^6$	46·40
Heat to cooling water per hour ..	$1·286 \times 10^6$	17·94
Heat to piston cooling oil per hour	$0·307 \times 10^6$	4·28
Heat to exhaust per hour	$2·190 \times 10^6$	30·56
Heat unaccounted for—radiation, &c.	$0·059 \times 10^6$	0·82
	$7·166 \times 10^6$	100·00
Heat to brake work per hour ..	$2·552 \times 10^6$	35·61
Heat to friction and driving air compressor	$0·772 \times 10^6$	10·77
Heat to indicated work per hour ..	$3·324 \times 10^6$	46·38

TABLE V.—RESULTS OF PROFESSOR WATKINSON'S TESTS OF A FRASER AND CHALMERS HEAVY OIL ENGINE. SUMMARY OF DATA.

Test Number.	1	2	3	4	5	6	7
1. Date, 1923	Nov. 20	Nov. 20	Nov. 20	Nov. 20	Nov. 21	Nov. 21	Nov. 21
2. Duration of test	3 hours	3 hours	2 hours	2 hours	2 hours	4 hours	2 hours
3. Barometer reading in inches of mercury	29·52	29·49	29·49	29·51	29·66	29·69	29·71
4. Temperature of air in engine-room, deg. F.	53·6	52·7	50·0	49·6	49·6	54·9	57·6

TABLE VI.—PRESSURE MEASUREMENTS.

5. Blast pressure	lb./sq. in. gauge	1000	900	875	875	900	1040	1100
6. Starting air	" "	800	800	800	800	800	800	800
7. Air compressor H.P. discharge ..	" "	1000	900	875	875	900	1040	1100
8. Air compressor I.P. discharge ..	" "	220·4	198·7	196	205	137	230	240
9. Air compressor L.P. discharge ..	" "	30	25	25·25	28·25	23·0	31·9	34
10. Water service in cylinder jackets Inlet ..	" "	10·8	13·4	11·8	12·7	11·0	10·4	10·3
11. Water service in cylinder jackets Outlet ..	" "		Atmospheric.					
12. Piston cooling oil service Inlet ..	" "	18·15	17·6	18·0	17·75	15·25	18·34	19·0
13. Piston cooling oil service Outlet ..	" "		Gauge out of order.					
14. Forced lubrication Inlet ..	" "	28·65	28·8	28·5	28·5	26·0	26·0	26·0
15. Forced lubrication Outlet ..	" "	22·0	22·0	22·0	22·0	20·0	20·0	20·0
16. Piston oil cooler Oil inlet ..	" "	19·6	19·1	19·75	19·5	16·8	19·37	19·75
17. Piston oil cooler Oil outlet ..	" "	20·5	20·2	19·1	19·5	17·5	19·3	19·5
18. Piston oil cooler Water inlet ..	" "	11·8	14·0	10·6	11·6	9·0	11·3	16·0
19. Piston oil cooler Water outlet ..	inches of water	10·0	21·52	12·8	12 3	8·64	11·34	14·25
20. Lubricating oil cooler Water inlet ..	lb./sq. in. gauge	11·5	12·21	10·5	11·0	10·0	11·4	14·9
21. Lubricating oil cooler Water outlet ..	" "	11·5	13·0	11·1	11·4	10·25	11·84	16·0

TABLE VII.—TEMPERATURE OF EXHAUST GASES, DEG. F.

22. From cylinder No. 1	780	640	490	330	220	780	840
23. " " No. 2	735	595	420	215	400	720	800
24. " " No. 3	780	560	390	330	90	900	1010
25. " " No. 4	790	600	425	290	80	700	850
26. Means	771	599	431	291	197	775	875

TABLE VIII.—SUMMARY OF RESULTS OF THE TESTS.

1. Duration of test in hours	3	3	2	2	2	4	2
2. Revolutions per minute, N.	300·0	299·8	301·6	301·3	302·5	300·5	301·1
3. Indicated mean effective pressure, lb./sq. in.	108·0	85·4	64·8	48·3	49·0	107·7	120·5
4. Brake mean effective pressure, lb./sq. in.	82·6	62·0	41·3	20·7	—	82·6	95·0
5. Indicated horse-power	1306·6	1033·1	788·1	586·3	299·0	1305·1	1463·6
6. Brake load in lb., W.	2333·3	1750·0	1166·7	583·3	—	2333·3	2683·7
7. Brake horse-power = W × N/700	1000·0	749·7	502·7	251·0	—	1001·7	1154·4
8. Mechanical efficiency B.H.P./I.H.P.	76·5	72·6	63·8	42·8	—	76·8	78·9
9. Weight of fuel oil used per hours, lb.	402·1	304·6	218·85	148·1	74·96	399·1	470·5
10. Weight of fuel oil used per B.H.P. hour, lb.	0·402	0·406	0·435	0·59	—	0·398	0·407
11. Weight of fuel oil used per I.H.P. hour, lb.	0·308	0·294	0·278	0·253	0·251	0·306	0·321
12. Thermal efficiency on indicated horse-power (lower calorific value)	46·0	48·1	51·0	56·2	56·5	46·4	44·2
13. Thermal efficiency on brake horse-power (lower calorific value)	35·2	35·0	32·6	24·1	0	35·7	34·8
14. Power required to drive air compressor (from other tests)	98·0	95·0	90·0	85·0	80·0	98·0	100·0
15. Cooling water for power cylinders, outlet (temp. deg. F.)	117·8	123·3	124·1	114·1	91·5	117·0	98·4
16. Piston cooling oil, outlet temp. deg. F.	160·8	149·4	133·7	118·1	105·4	171·4	182·0
17. Exhaust gases, per cent. CO_2	5·76	5·0	3·3	1·86	2·33	6·66	8·41
18. " " " O_2	12·7	13·8	16·0	18·0	17·5	11·65	9·39
19. " " " N_2	82·2	81·2	80·7	80·1	80·0	82·2	82·2
20. " " " temperature in exhaust pipe deg. F.	771·0	599·0	431·0	291·0	198·0	775·0	875·0

(*a*) During the no load test, No. 5, the fuel oil supply to two cylinders was cut off.
(*b*) The low temperature of the cylinder cooling water during test No. 7 was due to the increased pressure in the main, after the works shut down at night, causing a more rapid flow.

The average value of I.H.P.—B.H.P. was 300·8, and of this approximately 100 h.p. was absorbed in driving the air compressor, as shown by independent tests of the air compressor. The curve of mechanical efficiencies given in Fig. 5 shows that the mechanical efficiencies of this engine are considerably higher than is usual in engines of the Diesel type, with air injection.

Table IV, based on the lower calorific value of the oil, shows the distribution of heat for test No. 6.

from vibration. The starting of the engine was in all cases effected within a few seconds and without any hitch. The governing of the speed was exceptionally good at all loads, and when the load corresponding to 1,154 brake horse-power was suddenly thrown off, the tachometer showed a momentary increase in speed of less than 2 per cent., and it became normal again within a few seconds. During the overload trial there was no indication that the engine was overloaded, the exhaust gases were invisible, and the engine worked as smoothly as it did at all other loads. There was no indication that there was any limit to the time during which the engine would work under this load.

Professor Watkinson also remarks that, on the day following the completion of the trials, he saw one of the pistons withdrawn from its cylinder. The cylinder liner was in perfect condition and had a brilliant polished surface, without a visible scratch. The piston and its rings were also in perfect condition, as also was the oil fuel valve.

INDUSTRIAL NOTES.

WE are glad to report that the voting at the miners' delegate conference, held as announced in our last issue, resulted in a majority in favour of accepting the new agreement. This involves a large number of additional sacrifices on the part of the coalowners, made by them with a view to secure peace in the coal-mining industry. The votes given for acceptance were 473,000, and for rejection 311,000—a majority for acceptance of 162,000. The voting followed a statement by Mr. Herbert Smith, president of the Miners' Federation, to the effect that the miners had not obtained all they wanted, but all that they believed was possible under present circumstances. The leaders, in view of the position, recommended acceptance of the new terms. The alternative was to bring the men out on strike. He then pointed out the advantages gained since the last conference. If accepted, he added, the new terms would be retrospective to May 1. The agreement, we may add, is for twelve months; the period of notice of termination is one month, a period which the owners consider much too short, but it was the longest the miners would accept. The new terms as submitted to the conference and on which voting took place are briefly as follows:—

Standard profits to be 15*l.* per 100*l.* paid in standard wages, instead of 17*l.* as under the old agreement.

The surplus income to be divided in the proportions of 88*l.* in wages to 12*l.* in profits, instead of 83*l.* in wages to 17*l.* in profits as at present.

The minimum wage to be increased from 20 per cent. to 33⅓ per cent. on the 1914 wage.

In no district shall the wage of any adult able-bodied day wage workman fall below 40 per cent. above the standard wages of the lowest paid class of day wage workmen in the district.

For improving the position of the lower-paid classes of day wage men, the subsistence wage and allowances already fixed by the District Boards shall be increased by one-eighth.

There shall be effective recoupment of deficiencies below standard profits, but only one-third of any future surplus available in any one ascertainment shall be so applied, and the remaining two-thirds shall be divided between wages and profits.

The owners undertake to deal in the district with cases of anomalies in the wages of men at or near the wage of the lowest paid men.

It is reported that the new terms will have the effect of raising the wages bill of the British collieries by 200,000*l.* per week, provided the full volume of trade is maintained.

The result of the building trade ballot, mentioned on page 670 *ante*, was announced last Friday. The votes given for the acceptance of the employers' terms were 68,967, and against 41,516, making a majority for acceptance of 27,451. The men wanted an advance of 2*d.* per hour. The employers first offered a half-penny advance, which was refused. They ultimately confirmed their offer of a half-penny advance, combined with a modification in the operation of the sliding scale based upon the cost of living, a consolidation of rates, and consideration of the London position by a special committee. These were the terms accepted by the ballot. Further joint meetings are to be held to deal with the final settlement in regard to matters of detail. Difficulties, however, are anticipated by adverse action on the part of building trades operatives in the Liverpool and Birkenhead districts.

At the moment of going to press some of the services of the London railways have been interfered with by an unauthorised strike. The strike has been brought about by an unofficial strike committee with the object of bringing about an improvement in the condition of railway shopmen in London. Those responsible for the agitation claim an advance of 10*s.* a week, a minimum wage of 3*l.* a week, the consolidation of the 16*s.* 6*d.* war wage, and a week's holiday per year on full pay. These demands have been made to the London Electric Railways and the Great Western Railway Company. The companies replied that they could not negotiate with an unofficial body and the N.U.R. and Electrical Trades Union do not recognise the strike. Yesterday morning (Thursday) some forty "Tube" stations were reported closed, the majority of the staff at Lots-road power station having ceased working. It is also stated that the Associated Society of Locomotive Engineers and Firemen have decided to demand a revision of conditions.

The report for the quarter from December 30, 1923, to March 29, 1924, issued by the Associated Blacksmiths and Ironworkers' Society, states that the membership at the close of the quarters was 12,373, a decrease of 86 compared with the preceding period. The total income for the quarter, including 14,316*l.* from the Ministry of Labour and 2,284*l.* from the Board of Health, was 22,197*l.* The total expenditure was 22,319*l.*, and included 13,977*l.* for State Unemployment Benefit and Administrative Expenses, and 2,284*l.* for State Health Insurance and Administration. The loss on the quarter's transactions was 122*l.*, the lowest recorded for some time; it was hoped that this improvement would continue.

Speaking last Friday at the Annual General Meeting of Messrs. Vickers, Limited, held at the River Don Works, Sheffield, Mr. Douglas Vickers called attention to the reference made in the company's report to the probable effect of the suspension of the McKenna duties in the sections of the works making forgings, stampings, springs and other motor-car component parts. He stated that the aggregate effect must be a reduction in output equivalent to the number of cars imported, since the English market could only absorb a certain number yearly. The Government's decision in regard to the duties was doubly unfortunate at a time when the figure of unemployment still stood so high, and when our outside markets were being gradually restricted by protective duties imposed by other Governments and by some of our Colonies and India, with the deliberate intention of encouraging their home manufacture of goods which we used to send from here. From the company's experience, the final result of the suspension of the duties will be loss by the Government of the duty remitted, the profits of the foreign maker will be increased and the reduction of price to the consumer will be small.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The 50*l.* prize placed at the disposal of the Institution of Automobile Engineers by the Humber Company and allocated by the Council for the paper which would best enable the British manufacturer to regain the colonial market has been awarded jointly to Mr. F. A. S. Acres for his paper entitled "The Requirements of the Colonial Market" and to Mr. E. A. Rouch for his paper entitled "The Overseas Automobile Market." The paper by Mr. Acres will be read at a special conference to be held in No. 3 Conference Hall at the British Empire Exhibition on Monday, June 23, at 11.30 a.m. The paper by Mr. Rouch will be read at 3 in the afternoon of the same day and in the same hall.

EXHIBITION OF INVENTIONS.—The Institute of Patentees will hold an exhibition of inventions from August 11 to August 16 next in Aldwych House, Kingsway, London. Prizes are to be awarded for the best inventions, and there will be two prizes for women. The exhibition will be divided into eight sections, as follows: (1) Domestic and Labour Saving (excluding Mechanical and Electrical); (2) Mechanical (excluding I.C. engines, &c.); (3) Electrical (excluding wireless); (4) I.C. Engines and Inventions appertaining thereto; (5) Wireless; (6) Building; (7) Novelties and Toys; (8) Miscellaneous. Correspondence on the matter should be addressed to the General Secretary of the Institute of Patentees, 44, Great Russell-street, London, W.C.1.

MANCHESTER ASSOCIATION OF ENGINEERS.—As announced on page 671 *ante*, the members visited on May 29 the locomotive works of the Vulcan Foundry Company, Limited, Newton-le-Willows. These works were established in 1830 by Charles Tayleur, who was subsequently joined in partnership by Robert Stephenson until his appointment as engineer of the London and Birmingham Railway. The concern was transformed into a limited company in 1864. The company has just completed an order for 20 large goods engines and tenders for the Bengal Nagpur Railway, and is now commencing the delivery of 20 tank locomotives for the London, Midland and Scottish Railway. Amongst other orders in hand are four engines and tenders for the Crown Agents for the Gold Coast Railways, and 40 heavy passenger engines and tenders for the East Indian Railway, besides 70 boilers for British railways.

NOTES FOR SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The persistence with which the big steel and engineering companies in this district are compelled to pass dividend payments furnishes solid proof of the manifold difficulties through which the staple industries are passing. The trouble is not so much that work cannot be obtained (though in some sections organisers are extended to the limit of their enterprise to obtain sufficient renewals to cover expiring contracts), as that, owing to the keenness of local and foreign competition and to the general inability of consumers to pay high rates, it has been necessary to prune quotations to such an extent that when the standing burden of rates, taxes and other overhead charges has been met, there remains little, if any, profit for distribution. The armament branches, which perhaps have suffered most severely on account of the restrictions imposed by the Washington Treaty, are partially engaged on work mainly for the British Government, but in the continued absence of any form of financial assistance or prospect of such assistance, the position gives rise to very anxious thought as regards future arrangements. Some benefit has accrued from increased concentration on the production of machinery and materials for the transport, electrical and allied trades, though in the most favourable instances the additional work so attracted is insufficient to compensate for the slump in armament requirements. Orders for plant and machinery for steel works have fallen off, the current paucity of cash making it impossible for manufacturers to embark on costly extensions. Tool makers are doing a much more robust business with overseas customers. They are steadily returning to the pre-war practice of laying themselves out to meet the special needs of export buyers. Any change in the market for raw and semi-finished materials is in the direction of slightly easier prices. Official quotations are as follows:—Hard basic billets, 10*l.* per ton; soft basic billets, 9*l.*; West Coast hematites, 5*l.* 15*s.*; East Coast hematites, 5*l.*; Lincolnshire No. 3 foundry, 4*l.* 15*s.*; Lincolnshire forge, 4*l.* 10*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bars, 13*l.*; sheets, 15*l.*

South Yorkshire Coal Trade.—While in exceptional instances housecoal distributors are inclined to make further cuts in wholesale prices, official quotations remain the same as a week ago. The demand for local and Southern consumption, however, shows a big contraction, and there is little prospect of improvement. The weakness which has recently developed in steam hards tends to become more acute owing to the continued fall in the export demand. Concurrently, home requirements are on the downward grade. Yorkshire best steams have been further reduced an average of 1*s.* 3*d.* per ton. There is a fair demand for slacks for provincial use. Quotations:—Best branch handpicked, 34*s.* to 35*s.*; Barnsley best Silkstone, 28*s.* to 29*s.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house, 25*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 23*s.* 6*d*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

STANDARD METHODS OF TESTING PETROLEUM AND ITS PRODUCTS.—Under this title the Institution of Petroleum Technologists, of Aldine House, Bedford-street, W.C.2, have published (at the price of 6*s.* net, bound) a booklet of 102 pages, representing the results of several years of very useful work. The Standardisation Committee of the Institution was appointed in 1921, and credit for having promoted the work is in particular due to Professor Brame, who was president of the Institution in 1922-23. Six such committees have been deliberating in conjunction with various Government departments, the British Engineering Standard Association and the National Physical Laboratory, as well as with the American Society for Testing Materials and the American Bureau of Standards. The agreement with the American bodies is, of course, of great value. Mr Alexander Duckham was chairman of the committee; the experts of the sub-committees dealt with naturally occurring bituminous substances, distillates up to kerosene, kerosene and intermediates, lubricants, liquid fuels, and asphaltum and artificial residues. The settling of these tests will avoid much confusion and litigation.

THE ROYAL AERONAUTICAL SOCIETY.—We are informed that the Royal Aeronautical Society's silver medal for the year has been awarded to Squadron Leader R. M. Hill, for his paper entitled "The Manœuvres of Inverted Flight," which was published in the issue of the Society's Journal for December last. It is also announced that a sum of twenty guineas, derived from the Edward Busk Memorial Fund, will be offered as a prize for the best paper received on some subject of a technical nature in connection with aeroplanes or seaplanes. The prize is open to international competition, and intending competitors should forward their names to the Secretary of the society, at 7, Albemarle-street, London, W.1, on or before September 30 next, together with such information as to the proposed scope of their papers as will enable arrangements to be made for examining them. The latest date for the receipt of the papers will be December 31 of this year. We may, perhaps, remind our readers that Edward Teshmaker Busk, to honour whose memory the prize is offered, was the designer of the R.E. 1, which was the first inherently-stable aeroplane. He was killed in this machine at South Farnborough in November, 1914, in consequence of its taking fire in the air.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Extreme quietness characterises the Cleveland pig-iron trade. Sales are few and small, and values are steadily falling notwithstanding makers' great reluctance to acknowledge reductions. It is really difficult to ascertain on what terms a fairly good order could be placed, but it is safe to assume that, for such business, offers at below current rates would receive favourable consideration. No. 1 is now obtainable at 95*s.*; No. 3 g.m.b. can be bought at 90*s.*; No. 4 foundry is put at 89*s.*; and No. 4 forge is quoted 88*s.* These prices are f.o.b. Tees and can be shaded for parcels f.o.t. at makers' works.

Hematite.—East coast hematite is very slow of sale, customers holding off in anticipation of further falls in prices. Export demand is trifling, and inquiries from the Sheffield and South Wales districts, as well as on local account, show shrinkage. Nos. 1, 2, and 3 are offered at 98*s.*, and No. 1 is on sale at 98*s.* 6*d.*

Foreign Ore.—There is next to nothing doing in foreign ore. Consumers are well placed and are off the market. Sellers base quotations on best rubio at 23*s.* 6*d.* c.i.f. Tees, but possibly purchases could be made on slightly lower terms.

Blast-furnace Coke.—Durham blast-furnace coke is decidedly easier. Makers declare that quotations are unremunerative, and that more plant will have to be laid idle if the position does not improve in the near future. Good average qualities at 27*s.* to 28*s.* delivered to local consumers.

Manufactured Iron and Steel.—Nearly all descriptions of manufactured iron and steel are in poor request and easy in price. Shipbuilding material, however, is steady, and a good demand for corrugated sheets has stiffened values. Quotations: common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.*; steel ship, bridge, and tank plates, 10*l.* 5*d.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and corrugated galvanised sheets (24 gauge, in bundles), 18*l.*

Imports of Iron and Steel.—Returns of the Tees Conservancy Commission just issued show imports of iron and steel to the River Tees from Holland, Belgium, France, Norway, Germany, India, and coastwise for the seven months to the end of May last, the figures for the same months of a year ago, and for the corresponding pre-war period of 1913–14. Imports of pig-iron for the past seven months amounted to 15,285 tons, as against 4,592 tons a year ago and 181 tons for the pre-war period; plates, bars, angles, rails, sheets, and joists unloaded to the end of May last are given at 10,767 tons, as against 7,146 tons a year ago and 15,124 tons for the pre-war period; and crude sheets, bars, billets blooms, and slabs brought in during the past seven months totalled 46,158 tons, as against 38,276 tons a year ago and 27,413 tons for the pre-war period.

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees last month totalled 135,294 tons, of which 66,659 tons were pig-iron, 4,184 tons manufactured iron, and 64,451 tons steel. As regards pig-iron, 10,274 tons went from Skinningrove and 56,385 tons from the port of Middlesbrough, 43,488 tons of the latter going to foreign ports and 12,897 tons to coastwise destinations. The chief customers for pig-iron were Belgium, 8,782 tons; Germany, 7,512 tons; Italy, 7,290 tons; France, 5,367 tons; Wales, 5,160 tons; Scotland, 4,675 tons; and Sweden, 3,006 tons. Of the manufactured iron despatched, 3,925 tons went abroad and 259 tons went coastwise; and of the steel loaded, 54,001 tons went abroad and 10,450 tons went coastwise. As usual, India was the largest receiver of both manufactured iron and steel, taking 1,112 tons of the former and 19,537 tons of the latter. Among other principal importers of steel were: Argentine, 8,657 tons; New South Wales, 3,653 tons; Japan, 3,305 tons; Natal, 2,721 tons; Victoria, 2,526 tons; Straits Settlements, 2,387 tons; Queensland, 1,427 tons; West Australia, 1,391 tons; and the Cape of Good Hope, 1,201 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The course of general trade throughout the country of late has not been such as to make for any improvement in the Scottish steel trade. The demand during the past week has again been poor, and as it is only six weeks now until the stoppage in the Glasgow district for the annual Fair Holidays, we are doubtful of much influx of dealing before then. There is nevertheless quite a good undertone and makers are hoping to book a sufficiency of new business in the near future which will give them a good start after the holidays, and be the means of keeping much more plant in daily operation than is now possible. The conditions, at present, are undoubtedly very poor, and most works are badly in need of some orders for early delivery. The black sheet trade is also very dull both for home and export lots, but the inquiry for shipment is again a turn better. Prices keep steady and are as follows: Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{7}{8}$ in. to $\frac{1}{2}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been no change in the malleable iron trade of the West of Scotland over the week and a very small inquiry is reported. The business booked is not of much account from a tonnage point of view and plant is only running intermittently. The current quotation for "Crown" bars is 12*l.* 10*s.* per ton, delivered Glasgow stations and is therefore unchanged. Business in the steel re-rolling branches continues fair, and although there is quite a lot of work on hand more would be gladly welcomed.

Scottish Pig-iron Trade.—In the Scottish pig-iron trade there is little fresh to report. The demand has not improved, either on home or export account, and inquiries for shipment lots are not very encouraging. No alterations have been made in prices which are as follow:—Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3 5*l.* per ton, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The shipments for Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 31, only amounted to 699 tons. Of that total, 475 tons went overseas and the balance, 224 tons, went coastwise. For the corresponding week of last year the figures were 2,195 tons to foreign ports and 35 tons coastwise, making a total shipment of 2,230 tons.

Scottish Shipbuilding.—Some improvement falls to be noted in the shipbuilding industry of Scotland, and the figures of the past month tend to show that employment is better. The vessels launched during May numbered 42, with a total of 48,214 tons. The output for the different districts is as follows:—

	Vessels.	Tons.
The Clyde	38	44,390
The Forth	1	1,284
The Tay	—	—
The Dee and Moray Firth ...	3	2,540
Total	42	48,214

The Clyde figures are the second highest for the year to date, the month of March being better, with a total of rather over 58,000 tons, but they represent the highest tonnage for the month of May since 1920, when 61,735 tons was the output. The tonnage launched this year now amounts to 184,296, which is very satisfactory, and although not up to the standard of former good years it is nevertheless round about 50,000 tons better than the totals for the corresponding five months of the past two years. The number of vessels included in the Clyde total for the past month is large compared to the total tonnage, but many of these were small vessels of the pleasure type, which, all the same, mean work in the yards. The analysis of the figures shows 20 vessels of from 3 to 83 tons, five between 100 and 750 tons, six from 1,000 to 2,000 tons, and seven from 2,000 to 9,200 tons. The new contracts booked during the month are mostly for trade purposes, but one is for a liner of 22,000 tons. The new vessels ordered over the month number about a dozen on the Clyde and three on the East Coast. The latest contract announced is one secured by the Blythswood Shipbuilding Company, Limited, Scotstoun, for two twin-screw oil tankers, each of 500 ft. in length and 13,000 tons deadweight, for Norwegian owners. One of these vessels is for Christiania and the other for Hangesund. They will have a speed of 11 knots and will be propelled by Burmeister & Wain—Harland and Wolff Diesel engines made by Messrs. John G. Kincaid and Company, Greenock.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Unauthorised sectional stoppages in the coalfield and threats of strikes on the railway and at the docks have had a disorganising effect on the coal trade. Despite a strike by some 15,000 miners and the temporary throwing out of employment of another 3,000, as the result of a fire at one of the electrical pumping houses, and the consequent loss of production, prices generally have not shown any appreciable alteration, as the available supply remained sufficient to meet the demand. The 15,000 men out in the Sisbewy Valley over a dispute at the Marbbam Colliery of the Tredegar Iron and Coal Company, Limited, have been instructed to resume work by the Miners' Federation, it being conceded that the stoppage is unofficial and unconstitutional. The matter in dispute is first to be dealt with by the local pit committee and the management, and, failing a settlement, a deputation may wait on the general manager of the company. Then, if no agreement is reached, the matter will be dealt with by the Joint Standing Disputes Committee. Trouble is also threatened in connection with the working of double shifts, while the non-unionist question is also being talked about and threats are being made to cease work to bring the delinquents into line. In the circumstances, it is not to be wondered at that foreign consumers are rather chary of placing orders for Welsh coal in view of the uncertain outlook and the possibility of shippers being unable to give regular deliveries. Meanwhile best Admiralty large coal rules from 27*s.* 6*d.* to 28*s.*; with seconds round 27*s.*; Monmouthshires from 24*s.* to 27*s.*; and smalls from 15*s.* to 18*s.* 6*d.* according to quality. The miners are having three days' holiday next week and the coal-trimmers two days, with a short shift of 4 hours instead of 8 hours on Wednesday.

Iron and Steel.—Exports of iron and steel goods from South Wales last week totalled only 8,604 tons, compared with 23,759 tons in the preceding six days. Shipments of tinplates amounted to 5,867 tons against 16,053 tons; blackplates, 1,337 tons, against 3,844 tons; galvanised sheets, 906 tons, against 3,034 tons; and other iron and steel goods to 494 tons, against 827 tons.

NOTICES OF MEETINGS.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, June 11, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Informal Meeting. "General Observations on the Radio Situation and the Development of Broadcasting in New Zealand," by Mr. A. H. Ninnis.

THE OPTICAL SOCIETY.—Thursday, June 12, at 7.30 p.m., at Imperial College of Science and Technology, South Kensington, S.W. 7. "Wide Angle Orthostereoscopy: Its Optical, Practical and Psychological Advantages," by Colonel L. E. W. van Albada (of Amsterdam). "Binocular Vision and the Stereoscopic Sense," by Mr. R. J. Trump, B.Sc. "Some Problems in the Theory of Optical Diffraction," by Mr. E. T. Hanson, B.A. "A General Solution of the First Order Aberrational Conditions," by Mr. T. Smith, M.A., F.Inst.P.

THE SURVEYORS' INSTITUTION.—Sir Edwin Savill, 51A, Lincoln's Inn Fields, London, W.C., has been elected President of the Institution for the coming year, and Mr. J. D. Wallis, Manchester, Mr. Dendy Watney, London, Mr. H. M. Cobb, C.B.E., Rochester, and Mr. E. A. Rawlence, Salisbury, Vice-Presidents. The new Members of Council elected at the recent ballot were Mr. C. Chart, Croydon, Mr. W. Fraser, Glasgow, and Mr. Cuthbert Lake, London.

PERSONAL.—Mr. William Corin, now in practice as consulting hydraulic, mechanical and electrical engineer, has moved his office to South British Building, 28, O'Connell-street, Sydney.—The Power Speciality Company, Limited, inform us that, owing to the extension of their business, they have found it necessary to acquire larger offices at Aldwych House, Aldwych, W.C. 2, to which communications should be addressed in future.—The Bristol office of the British Reinforced Concrete Engineering Company, Limited, is now at Sun Buildings, Clare-street, Bristol, the telephone number being Bristol 5544; telegrams should be addressed to British Reinforced, Sun Buildings, Bristol.

NATIONAL DIPLOMAS IN MECHANICAL ENGINEERING.—The Institution of Automobile Engineers announce that the Council of the Institution of Mechanical Engineers have agreed to the principle of the endorsement by the Institution of Automobile Engineers of diplomas in mechanical engineering in respect of automobile engineering subjects. This will mean that it will be possible for members of the Institution of Automobile Engineers, in addition to passing the Institution examination, to obtain a special diploma endorsed by the Board of Education, the Institution of Mechanical Engineers, and the Institution of Automobile Engineers in regard to their technical qualifications. The details will be announced later.

LIQUID OXYGEN EXPLOSIVES, LIMITED.—CORRECTION.—On page 711 of our issue of May 30 we said that the oxygen cartridges of this company were filled with sawdust. We are asked by the company to state that this filling—which is not unusual—is used only for exhibition purposes, and that their cartridges normally contain various mixtures of a combustible nature combined with metallic powders and hydrocarbons, the selection depending upon the strength of the explosive required. Cartridges are made in dimensions: 12 in. long by $1\frac{1}{4}$ in. diameter, 19 in. by 2 in., and 18 in. by 3 in., and with a certain mixture, suitable for replacing high explosives, these sizes would be respectively equal to 10 oz., $2\frac{1}{4}$ lb. and 6 lb. of dynamite. Six types of mixtures are made. We regret the abovementioned misunderstanding.

CONTRACTS.—Messrs. Johnson and Phillips, Limited, Charlton, S.E. 7, have booked an order from the Sydney Municipal Council for four 6,200 k.v.a. three-phase forced oil-cooled transformers, this order being secured in face of world-wide competition.—The Westinghouse Brake and Saxby Signal Company, Limited, have recently obtained orders, through the Metropolitan Vickers Electrical Company, Limited, for 303 motor-driven air compressors, in connection with the electrification of the Southern Railway. They have also received orders from the London Electric Railways for 69 motor-driven air compressors.—The contract for the reconstruction of the Tokyo telephone system, which was utterly destroyed in the recent earthquake, has been awarded to the Nippon Electric Company, Limited, of Tokyo, an associate company of the Western Electric Company.

SWEDISH INDUSTRIES FAIR, GOTHENBURG.—Gothenburg will this year be again the scene of a Swedish Industries Fair, at which all branches of Swedish industry will be fully represented. An opportunity will be afforded of a thorough survey, not only of such staple products as iron and steel, paper and pulp and timber, but also of innumerable other high-class products in which Sweden specialises. The Gothenburg Fair is the only official national fair, and has the support of all the great commercial and industrial organisations of the country, each of which has established its information bureau. Interpreters will be available gratis, and careful arrangements have been made for providing suitable accommodation, at reasonable prices, for visitors. In addition to staple products, the main groups of exhibits include machinery and tools, metal products, sporting articles, heating, lighting and sanitary appliances, electrical apparatus and machinery, glass and porcelain, textiles, arts and crafts, instruments, chemicals, foodstuffs, &c. The Fair will be open from August 4 to 10.

THE AUSTRALIAN PAVILION AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 723.)

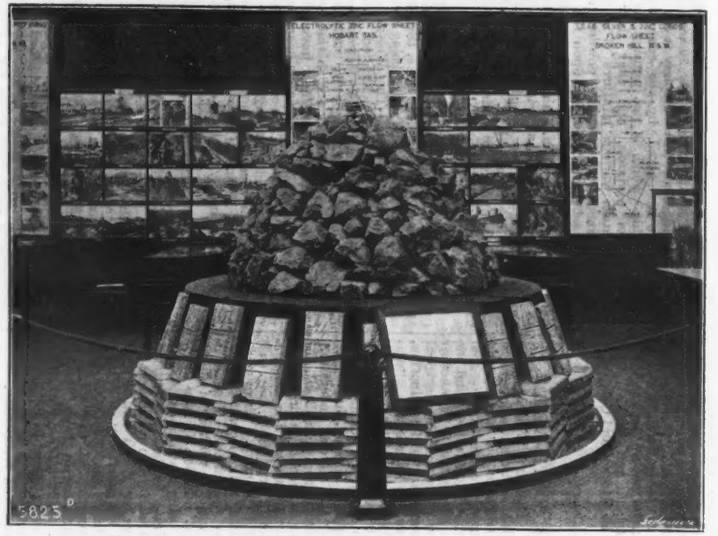


FIG. 4. TROPHY DISPLAYING METALS AND ORES.

FIG. 6. AGRICULTURAL MACHINERY EXHIBIT.

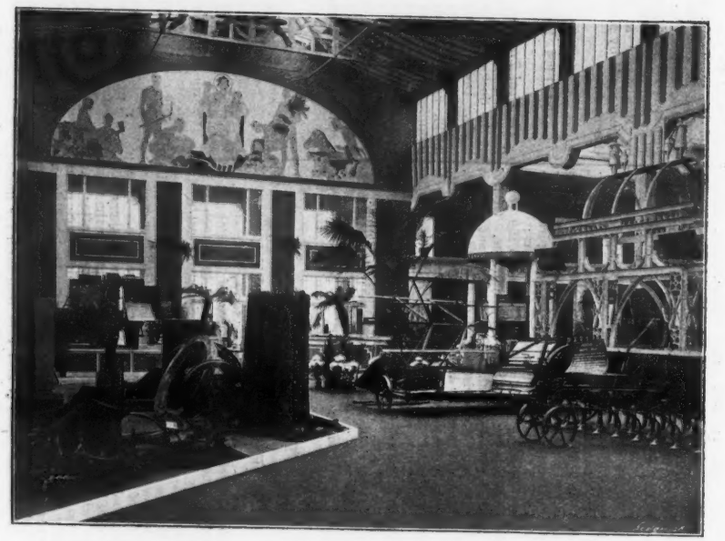


FIG. 5. AGRICULTURAL MACHINERY EXHIBIT.

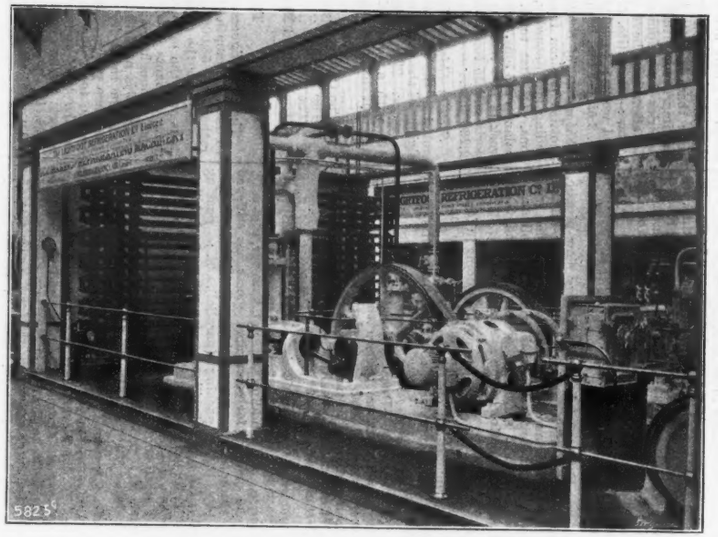


FIG. 7. REFRIGERATION PLANT.

ENGINEERING.

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One Two-Page Plate and Two One-Page Plates.—12,000-*KW.-STEAM TURBO-GENERATOR AT THE BRITISH EMPIRE EXHIBITION.*

ENGINEERING.

FRIDAY, JUNE 6, 1924.

SCIENCE AND LABOUR.

THE scientist is accustomed to methods of working and of deduction based solely on reason and experience, but the world conducts too many of its activities on systems depending upon the extent to which a plausible story momentarily pleases. In contrast to the exactitude of scientific method the affairs of mankind are dealt with in ways based on conjecture and prejudice, and the effects of this when seen to be bad are provided for with a similar lack of reason. The result is a waste of energy, time and money, and the path of progress is made unduly long and in places is entirely blocked by obstructions. With the hope that something approaching to reason may eventually be made possible in the service of government, in general administrative work and, indeed in all the affairs of men, the British Service Guild was founded and has done much by its propaganda to let the world know of the work of scientists and to show how the methods they use might be applied with benefit in other spheres. For the achievement of any reform it must first be shown that there is a necessity for the suggested change. The Guild has started this work and is attempting to convince people of all types of the soundness of their views. There are many difficulties, born of prejudice and ignorance, which have to be encountered before success is won, but the members of the British Service Guild are fighting on with the hope that eventually the methods of reason will prevail. The latest effort was made last Friday and Saturday, when a conference on Science and Labour was held in the British Empire Exhibition. The questions there discussed were those of Science and Government, Research in Relation to Industry, the Co-operation of Science and Labour in Production, Science and the Human Factor, and Science in Educational Organisations.

Mr. Ramsay Macdonald sent a letter to the Conference, which was read by Sir Richard Gregory. In this the Prime Minister said that he would have liked to have been present "to say something to impress upon the public the necessity of treating political questions in a scientific spirit and not merely in a short-vision partisan way. Until we regard administration and legislation in precisely the same manner as a scientific worker approaches his work in a laboratory we shall never get results of a permanent character." Such words from a political leader give hope for the future, and if they were fully accepted by all parties one would, indeed, see much discarding of deep-rooted political convictions, which have little of pure reason as a basis and, indeed, in many cases could be proved from previous experiences to be due to fallacies. The discussions afforded much information on the attitudes of the various interests concerned, and showed how they contrasted with each other. For instance, Sir Richard Gregory and Sir Richard Glazebrook argued for the ultimate advantage to industry and to the social life of the people of the application of deductions from scientific investigations and the necessity for the adoption by the Government of means to secure a plentitude of available scientific raw material. They suggested the need for greater interest on the part of the Government in scientific work, which could only be ensured by active co-operation of scientific men in the legislature, but Mr. Sidney Webb saw little hope of this and suggested that the scientists were generally not qualified for such work, and although their help was desirable, it should be given by experts as consultants to those laymen who possessed the characteristics suited to government.

The attitude towards research of the employers in great organisation was ably presented by Mr. Hugo Hirst of the General Electric Company. There are few people equally qualified to deal with the question, and his contribution must be considered as of great value to the conference because of the convincing way in which he demonstrated that the application of science lightens the burden of labour and ensures a reduction of costs of production and thus brings commodities within the reach of many who would otherwise not be able to afford them. The work done in the research laboratories of the large industrial companies is more intimately associated with the immediate and actual requirements of life than the adventures in pure science undertaken in university and college laboratories, and Sir Oliver Lodge showed his recognition of this by detailing the work of the pioneers in wireless telegraphy and telephony. It was a pleasure to hear this eminent physicist giving proper credit to the men of resource who gauged the significance of the work of the pure scientist and rendered it available to the service of mankind.

In some of the speeches which were made after the discussion on Science and Labour in Production was opened by a contribution of outstanding merit from Lord Ashfield, it was obvious that, though the attitude of labour to many questions implies a belief in activities at a greatly accelerated rate and even in violent changes, no such thing could be contemplated with equanimity in the minor matters concerning the individual activity of a workman. Lord Ashfield surveyed the stages by which economies in traction have been obtained and showed that, although each change may usually mean an immediate reduction in the number of employees necessary in any scheme, after a period the advantages which had accrued prompted extensions and improvements in service and the eventual employment of more men than ever. The trades unions, by their restrictions, have made the immediate absorption of workers, released in this way from one phase of activity into another, a matter of considerable difficulty and yet are prepared to demand that facilities should be provided by the State or the industry to make possible the early accommodation of the discharged workers. As an example, the activity of the Boilermakers' Society in dealing with welding may be cited. They demanded that when welding was used to replace a riveting process the full complement of men necessary for riveting should be employed, which meant that three men stood by idle while one man worked. The full attainment of the advantages of any new development and the consequent increased employment which would follow are thus restricted, and the cheapening of production, so essential to the reduction of unemployment, is made almost impossible. It is, therefore, desirable that something should be done to educate the labour

leaders in the methods of progress approved by the pure scientists, who have no financial interest in the matter, and by the employers whose concern is truly the obtaining of contented and happy workpeople, without which the attainment of the highest efficiency in a factory is well nigh impossible. A progressive change may cause a temporary hardship to individuals, but all the evidence shows that eventually the results are improvements in employment and increased facilities for the progress and happiness of all concerned, and very especially of the workpeople. There are methods, such as Taylorism, by which the output of a works may be increased enormously if the processes are of the repetition type. The introduction of these into our country has been made only in a very half-hearted way, though in America something more thorough is frequently to be seen. While labour can see much that is objectionable in the division of the actual work performed into so many stages that the activity of each worker is confined to some few simple manual movements, economies may be obtained in that way and cheap production results. The attitude of labour is that such work reduces the operatives to the level of machines. Objections there may be, but it must never be forgotten that the adoption of such methods in one country will cause competition which the other countries cannot meet unless they adopt similar processes. Production must be increased if we are ever to recover and retain our proper position in the export markets of the world, and any means to that end must be adopted, for otherwise the feeding of the population of our country will simply become impossible.

FUEL ECONOMY IN FLIGHT.

ALTHOUGH the expenditure on the fuel used for the operation of a commercial aeroplane service forms a by no means neglible proportion of the total running costs, the desire to reduce this expenditure is not the main incentive to fuel economy in flight. This statement, at first sight paradoxical, will be clear when it is pointed out that, in the case of a modern commercial machine having a cruising speed of 100 miles per hour and flying on the comparatively short route between London and Paris, a quantity of fuel of which the weight is about half that of the full paying load must be carried to complete the journey. A saving of 40 per cent. in the fuel consumption would thus enable the paying load to be increased by 20 per cent., a factor which would materially affect the balance sheet of an aerial transport concern even if petrol were obtainable gratis.

That such a saving could be attained within the next few years by possible improvements in design and methods of operation was the opinion expressed by Lieut.-Col. H. T. Tizard in the Wilbur-Wright lecture delivered at the Royal Society of Arts on the 29th ultimo, under the auspices of the Royal Aeronautical Society, and we can think of no more appropriate method of honouring the memory of the great pioneer of aviation than by directing attention to the means by which the efficiency of aerial transport may be increased.

The lecturer divided the subject into two parts, dealing mainly with the principles governing the most economical use of an aeroplane in flight having regard to the weather conditions, but also referring to design principles as affecting efficiency of operation. He first disposed of the prevalent idea that considerable economy results from flying at great altitudes, by showing, from theoretical considerations, that the range of any given aeroplane in still air depends only upon the indicated air speed and is practically independent of height; he mentioned, however, that this conclusion had not been put to a satisfactory practical test. Actually, Col. Tizard stated, the wind was the chief factor in determining the most economical height at which to fly, and since the strength of the wind usually increased with the height, it was, in general, more economical to keep as low as possible when flying against the wind and as high as possible when flying with a following wind. It is important to mention, however, that high flying is only advantageous when altitude controls are fitted to the carburettors. If no control is provided, fuel is always wasted by flying at high altitudes, whether the wind is favourable or contrary.

Assuming then that the results obtained in level flight near the ground are applicable at any altitude, the three quantities which affect the range of an aeroplane at any given indicated air speed are the drag of the machine, the fuel consumption of the engine per brake horse-power hour and the propeller efficiency. The last can be regarded as constant without greatly affecting the conclusions reached, but in connection with the matter of fuel consumption, the lecturer pointed out that the results obtained in bench trials of a throttled engine could not be directly applied to flight conditions owing to difference of carburettor adjustment and to the fact that the characteristics of an aeroplane as a dynamometer do not correspond exactly to those of a testing dynamometer. With an average aeroplane, in which the minimum speed in level flight may be taken as half the maximum, the minimum torque exerted by the engine would be about 64 per cent. of the maximum, and the maximum fuel consumption per brake horse-power hour at the point of minimum drag would be only 7 per cent. above the corresponding figure at maximum power. In still air, the maximum range would be obtained at the air speed at which the drag is a minimum, and the lecturer showed that this occurs at an air speed of from 1·2 to 1·3 times the minimum air speed level flight; the average minimum drag, he stated, was equal to 0·115 W, where W is the weight of the fully loaded machine. Assuming then an airscrew efficiency of 75 per cent. and a fuel consumption of 0·60 lb. per brake horse-power hour (corresponding to a consumption of 0·56 lb. per brake horse-power hour at full throttle) the fuel consumption in pounds per mile at the speed of minimum drag would be 0·00025 W lb., and the air miles travelled per gallon work out at 29,000/W.

As the result of a large number of tests carried out during the war with machines of widely varying weights, the lecturer said he had arrived at a figure of 28,000/W for the range, but he remarked that this figure was exceeded by the more efficient machines produced towards the later stages of the war, and he expressed the view that the figure 30,000/W might be taken, at the present time, as the average range in miles per gallon of a modern aeroplane.

Calculations of the range of an aeroplane in still air, however, are mainly of academic interest, since the effect of the wind on the actual range and on the amount of fuel which must be carried to complete a given journey is obviously of the utmost importance. For aerial transport to compete with other forms of transport, in this country at all events, it is essential that the speed over the ground should be at least equal to that of an express train, even in adverse weather conditions. For this speed to be attained it is necessary to provide for a cruising speed of 60 miles per hour in excess of the highest wind likely to be encountered, and, from a careful analysis of meteorological data, the lecturer concluded that a reasonable allowance for the velocity of head winds on the London to Paris route is 40 miles per hour. The highest cruising speed should thus be 100 miles per hour, and, having determined this, it is important to ensure that the drag of the aeroplane is as low as possible at this speed. Now the minimum wing drag occurs at a speed of about 1·7 times the minimum flying speed V_0, so that it is necessary to fix the wing loading to give the minimum speed a value at which $1{\cdot}7\ V_0 = 100$, or $V_0 = 59$, which corresponds to a loading of 9·6 lb. per square foot. Since the total weight of the machine varies during flight owing to the fuel consumed, the loading mentioned should be the figure at the middle of the flight and the loading at the commencement of the flight may be about 10 lb. per square foot. There is room for some difference of opinion as to the best value of the wing loading, but the lecturer's view was that the last-mentioned figure is not only the most efficient aerodynamically, but also offers the best practical compromise.

Under these conditions, and assuming an average figure of 0·072 W for the body drag, the lecturer showed that the petrol consumption per mile should not exceed 0·00025 W, so that, against a head wind of 40 miles per hour, the total fuel consumption for the 230-mile journey between London and Paris would be $0{\cdot}00025\ W \times 100/60 \times 230 = 0{\cdot}096\ W$. This figure gives a slight margin, since no allowance is made for the reduction in weight due to the fuel consumed. The corrected figure would be about 5 per cent. lower, or say 0·091 W, and with a 15 per cent. margin to cover all contingencies the total amount of fuel to be provided would be 0·105 W, *i.e.*, just over one-tenth of the weight of the fully-loaded machine.

The concluding portion of the lecture was devoted to the consideration of the directions in which to look for possible improvements in fuel economy in the future. Colonel Tizard did not anticipate any substantial increase in propeller efficiency, which is already of the order of 80 per cent. or higher, and thought it was hardly possible to give a definite opinion as to the likelihood of a considerable increase being made in wing efficiency under conditions affecting the economy of aerial transport. Body drag, on the other hand, he thought might be materially reduced in the future. A retractable undercarriage, if it could be produced without increase of weight, would effect a considerable improvement and the employment of wing radiators, in place of frontal radiators, offered further possibilities. Apart from these features, however, the present knowledge as to the best shape for the fuselage of an aeroplane was very incomplete. As mentioned already, the body drag of a modern commercial machine is of the order of 0·07 W at 100 miles per hour, whereas the corresponding figures for the most efficient commercial machine was 0·06 W. The figure for the Curtiss racing machine, on the other hand, was probably less than half that for the most efficient British commercial machine. The lecturer therefore thought it not unduly optimistic to anticipate a reduction in body drag to a figure of 0·04 W at 100 miles per hour, which would represent a reduction of 40 per cent. in the present average figure and a 24 per cent. reduction in the total drag at that speed.

After discussing the disabilities of existing multi-cylinder engines and their possible reduction, either by direct injection or by stratification of the charge, the lecturer mentioned that preliminary experiments by Ricardo on the latter principle had indicated that a fuel consumption of 0·45 lb. per brake-horse-power hour could be obtained with a compression ratio of 5:1 and there appeared to be no reason for doubting that equally good results could be obtained with multi-cylinder engines of a size suitable for commercial aeroplanes. In its simplest form, the lecturer added, an engine working on this principle would be only slightly more economical than one of the ordinary type when developing full power, but there would be a very material reduction in the rate of consumption when the fuel supply was not sufficient to develop more than 90 per cent. of the maximum torque. The full power consumption, however, was of no great consequence, since full power was only required for comparatively short intervals—as for example when climbing.

These two possibilities together by reducing the head resistance at 100 miles per hour by 25 per cent., and by increasing the thermal efficiency of the engine by 20 per cent. at cruising speeds, would have the effect of nearly doubling the range of an aeroplane for a given consumption of fuel, and for a comparatively short journey of 250 miles against a head wind of 40 miles per hour, would enable the commercial load to be increased by over 20 per cent. and the cost of fuel to be reduced by over 40 per cent. An increase in the earning power and a reduction in the operating costs of commercial aeroplanes, such as that foreshadowed above, should do much to improve the prospects of aerial transport, which now depends mainly on financial considerations for its successful development.

THE UNIVERSITY COLLEGE, LONDON.

THE new buildings forming an extension to the engineering department of the University College of the University of London were opened for inspection on Wednesday last, and a number of interesting demonstrations were carried out in them, as well as in the original buildings. The new buildings, which were fully described in our issue of March 12, 1920,

on page 339, comprise the Charles Hawksley hydraulics laboratory, formed by excavating under the quadrangle adjacent to the existing buildings, and the addition of two floors above the old engineering laboratories. Of these two floors, the first is occupied by a number of research laboratories and a large laboratory for experimental work, while the second is utilised as a drawing office, giving accommodation for about 100 students. The sum raised for the work of reconstruction and equipment now amounts to about 53,500*l*., of which 10,000*l*. has been received from the London County Council, while a similar amount has been contributed by Viscount Cowdray. For the completion of the work, a further sum of 27,000*l*. is required, and we understand from the Treasurer of the fund, Sir Ernest Moir, Bart., that another donation of 10,000*l*. has been promised by Viscount Cowdray as soon as the other contributions have reached a total of 70,000*l*. For full particulars of the organisation of the engineering department, of which Professor E. G. Coker is the head, we must refer our readers to the article mentioned above, but we may add that the Ramsay Memorial Laboratory of Chemical Engineering, which is under the direction of Professor E. C. Williams, is accommodated in a building in Gordon-street, adjoining the chemical laboratories. For the next few years it is intended to use the old building, which has been reconstructed, for instruction in chemical engineering work and later, when further experience of actual requirements has been obtained, new buildings will be erected on the Gordon-street site.

THE LATE MR. LOUIS STERNE.

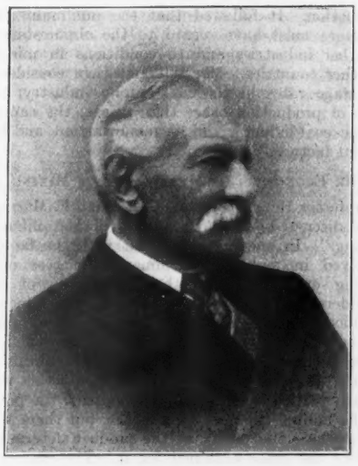
WE regret to place on record the death of Mr. Louis Sterne, one of the oldest and most respected engineering workers in this country. And yet there is no cause for regret, because for over 89 years he had lived a full life. In nis profession he did good work in various branches, although always unobtrusively. In the national life he, as an influential American, with the greatest regard for British traditions, played a distinctive part in promoting a continuance of the closest friendship between the great Anglo-Saxon races. Socially, he did much to round the corners of the busy man's life by his *bonhomie* and his great conversational gifts.

Mr. Sterne was born in Philadelphia on May 15, 1835. He started his education when five years of age, and began his apprenticeship in 1847, therefore at the early age of 12 years. He served two years with Messrs. Long and Co. of Philadelphia, and afterwards at the Baldwin locomotive works in the same city. It was one of his proud remembrances that during work in the foundry he assisted in welding work to repair a crack in a bell commemorating the foundation of the independence of the United States of America. At the end of his apprenticeship he proved so adaptable that he took a locomotive built by Baldwin to its station at Ohio. This episode seemed to have had the effect of awakening a spirit of adventure, because he never returned to the Baldwin works. He went south, and found there great scope for his inventive ingenuity in general mechanical engineering. He was in the repair works of the Louisville and Kentucky Railway, and later went westward, again in an adventurous spirit, and was engaged in charge of workers on one of the pioneer railways, an occupation which, because of the absence of satisfactory mechanical appliances, stimulated his creative mind. One result was the beginning of a long series of patents. In 1857 he returned to Philadelphia to take charge of his father's business and continued in this position until 1861, accepting the responsibility of many enterprises. During these years he became the personal friend of Abraham Lincoln. Naturally when the Civil War broke out he took an active part, and one of his hazardous adventures was the armouring, from crude material, of a barge conveying troops on the Potomac River. Soon afterwards Abraham Lincoln appointed him on special services to European countries, to prevent, as far as possible, the equipment of blockade runners for the Southern States.

At the age of 30, the war being over, Mr. Sterne decided to make England his principal country of residence. He was associated with the laying of the first Atlantic cable, and, under the late Mr. Greathead, in the construction of London's first tube railway by means of the Greathead shield.

This led to the founding of the firm in this country with which he was identified, Messrs. Thompson, Sterne and Co., a firm which achieved success when Mr. Sterne obtained for it from America the right to construct the De la Vergne system of refrigerating machinery. Mr. Sterne, however, introduced many important improvements, especially in cold storage engineering and refrigerating plant. The name of the firm was later changed to L. Sterne and Co., Limited, and it is still a well-known company, doing not only refrigeration but general engineering, including grinding and steel springs, at the well-known Crown Ironworks at Glasgow. He remained chairman of the company until the date of his death.

During this time he was identified with many



other undertakings, and one of his successful business enterprises was the Blackfriars Cold Storage Company, Limited. Associated with the late Thomas Mason he established the business, and was a director from the time the business was formed into a limited company, in the year 1910, until the date of his death. Mr. Sterne remained an American subject right to the end, with strong affection for Britain; indeed, on this point he was very pronounced, and was inclined to give the cold shoulder to such Americans as became naturalised. His old home, overlooking Kensington Gardens, was the rendezvous for prominent American and British subjects, and many diplomatic questions were thrashed out across his dining table. Rarely did a year pass without him crossing the Atlantic, particularly until the death of his brother, Mr. Simon Sterne, who was one of the leading authorities on international law in America.

He was elected a member of the Institution of Mechanical Engineers as long ago as February 27, 1876, and no engineer was better known or more highly respected. His company was much sought after, notably at the summer meetings of the Institution, when his gifts as a *raconteur* found full play and his courtesy and geniality were dominant factors in any social gathering. In the palmy days of the Whitehall Club he was one of its best-known members, his great friends among the members being the late Sir Miles Fenton, the late Mr. Albert Vickers, afterwards chairman of Vickers, Limited, and the late Mr. James Samuel Beale, for many years head of the firm of Messrs. Beale and Co., of Westminster, solicitors to the Midland Railway Company. In recent years he has been an equally well-known member of the Junior Carlton Club. He grew old beautifully. He never lost that kindly and courteous attitude towards friends, however new or remote they might be. He recognised that experience and judgment were the great assets of old men, and he conserved his physical energy by refusing to attend to any details, contenting himself with the bigger questions where his knowledge justified him in giving advice. Thus it was that, notwithstanding his great age, he continued serene, happy and active until the end. He motored during the last week of his life, and died peacefully at his beautiful flat overlooking the Thames at Whitehall Court, on Friday, May 30.

THE EMPIRE MINING AND METALLURGICAL CONGRESS.

THE opening meeting of the Empire Mining and Metallurgical Congress, of which H.R.H. the Prince of Wales is Honorary President, was held in the Conference Hall of the British Empire Exhibition on Tuesday of this week, when the Right Hon. Viscount Long of Wraxall, F.R.S., delivered an inaugural address on "Mineral Resources and Their Relation to the Prosperity and Development of the Empire."

In a survey of the mineral resources of the Empire, he said, it was natural to give coal the first consideration. From the very beginning of the modern era of coal exploitation on a large scale, Great Britain had been a leader among the producing nations. In fact, for a very long time Great Britain was easily first. In later years, however, the United States took the first position, with Great Britain second and Germany third. In 1913 the American yield of coal, including brown coal and lignite, was over 500,000,000 tons, or nearly 40 per cent. of the world's total, while Great Britain contributed 287,430,000 tons, or about 22 per cent., and Germany a little over 20 per cent. With this enormous annual production going on, it was natural to ask how long could it be expected to last. In Vol. II of "The Coal Resources of the World, 1913," the reserves of coal in Great Britain to a depth of 4,000 ft. were estimated to be 155,000,000,000 tons. There was thus reason for confidence regarding the future supplies, but it was necessary to husband wisely these resources. Coal was an important product in other positions of the Empire. Last year Canada had an output of 17,000,000 short tons of a value of 75,000,000 dols. To the end of 1922 British Columbia had produced coal and coke to the value of 240,000,000 dols., New South Wales 131,000,000*l*. and Queensland 25,000,000*l*.

Oil had become a vital necessity to us. In relation to world supplies we possessed within the Empire a very small percentage of the total, though individually at least three countries, Burma, Trinidad and Sarawak, must be looked upon as not inconsiderable producers. In spite of that handicap, British enterprise had played a large part in the development of the oil resources of the world. Russia, Mexico and the Dutch East Indies had all had British capital invested in their oil industries, while British engineers had taken an active part in their development. A fourth source to which special interest attached, because of its importance and the magnitude of British enterprise operating there, was Persia, which was now undergoing active exploitation by the Anglo-Persian Oil Company, in which the British Government was the largest shareholder. India, with Burma the predominating factor, produced last year about 303,000,000 gallons of oil, or rather over 1,000,000 tons. Trinidad in 1923 produced 430,000 tons, and Sarawak totalled 560,000 tons. Apart from the Scottish shales there were extensive deposits in Norfolk, Dorset and elsewhere, but these English shales have presented certain difficulties, chiefly of a chemical nature, which, it might be assumed, would eventually be overcome. Torbanite, a substance somewhat similar

to shale, was available in Australia, South Africa, Nova Scotia, Canada and in Great Britain.

In recent years the competition of richer or cheaper foreign iron ores had seriously affected the home production, but in 1922 the quantity of iron ore and ironstone raised amounted to not far short of 7,000,000 tons and had a value of 2,394,000*l*. Iron ore deposit of a remarkable character existed in Australasia, though only within recent years had endeavours been made to turn them to commercial use. The actual reserves in the various states of Australia had been estimated at over 344,000,000 tons, while probable and possible reserves were estimated at not far short of 600,000,000 tons. Iron ore was known to exist in the Northern Territory of Australia and in Papua. Extensive deposits were available in India. The Malay States, Ceylon and Hong Kong also swelled the Empire resources of iron ore. There were deposits in the Union of South Africa, in Rhodesia, Swaziland, and in East and South West Africa. Canada possessed great resources of iron ore. Great developments had been made during recent years in steel production in Canada, especially in Nova Scotia, where the presence of ample coal supplies was an important factor. Almost every known variety of iron ore existed in Newfoundland.

A vote of thanks to Lord Long was proposed by Sir John Cadman, seconded by Sir William Ellis, and supported by representatives of the Dominions of Canada and Australia, of India and also of the United States of America. During the morning a message was received from His Majesty King George congratulating the Congress on bringing together the mining and metallurgical authorities of the Empire and wishing success to the deliberations.

Papers from the Dominions.

Three communications from Canada, Australia and South Africa were received. The first was prepared by Mr. R. P. D. Graham for the Canadian Institute of Mining and Metallurgy, and dealt with "Mines and Mineral Deposits of Canada." The Australasian Institute of Mining and Metallurgy presented a paper, "An Outline of Mining and Metallurgical Practice in Australasia," prepared by many authorities in collaboration, and concerning coal, iron, gold, silver, lead and zinc, copper and tin. The last of the series related to practice in South Africa and was sub-divided into sections by different authors. "Coal in South Africa" was prepared by Mr. W. T. Heslop; "Notes on Deep Level Winding," by Mr. J. A. Vaughan; "Gold Metallurgy," by Mr. H. A. White; "Ventilation as an Agent in the Prevention of Miners' Phthisis on the Witwatersrand," by Mr. C. J. Gray; and "Health Problems in Mining," by Dr. A. J. Orenstein. These papers were remitted to the various sections for consideration and discussion.

In the afternoon visits were made to the mineral sections of the exhibits of the Dominions and India. A reception was held in the evening at the Royal School of Mines, by invitation of the Rector, Sir Thomas H. Holland, K.C.S.I., and Lady Holland.

The further proceedings of the Congress were carried on in four sections, Section A being devoted to consideration of mining subjects, Section B to petroleum, Section C to the metallurgy of iron and steel and Section D to non-ferrous metallurgy. We deal in this issue with the proceedings at these respective section on Wednesday, deferring our report of the proceedings of the four sections on Thursday until our next issue.

During the subsequent proceedings at one of the sections a message from H.R.H. the Prince of Wales was read, which expressed his hopes as Hon. President that the meetings would be productive of great benefit to the members and to the industry.

Section A. Mining.

In opening the proceedings of Section A on Wednesday morning the chairman, Sir John Cadman, extended a welcome to Mr. E. Shinwell, the Minister of Mines, who expressed his pleasure at being present at a meeting of the mining authorities of the Empire, and trusted that much good would come from the discussions of their many problems.

Economics of the Coal Mining Industry.

The first paper read in this section was on "Economics of the Coal Mining Industry," and was submitted by Mr. Evan Williams, the President of the Mining Association of Great Britain. In the period of 30 years before the war he stated that the average price of coal at the pit mouth rose by about 105 per cent. In the same period the Board of Trade index-number of wholesale prices fell from 125·9 to 116·5. The difference between the course of coal prices and of the prices of commodities in general was mainly due to the reduced output per person employed, coupled with the higher wages of the men and the fact that the cost of working coal gradually increased owing to the necessity for working at greater depths and in thinner seams than in the past. The upper limit at which a given output of British coal could be disposed of was dependent on world conditions since one-third of the British output was shipped abroad in competition with foreign coals. The heavy users in this country, such as the iron and steel trades, were also dependent on the export trade and the price they could pay was determined by the cost of production of their foreign competitors. The other extreme in coal prices was the cost of production. It followed that the minimum rate of wages must have regard to the circumstances of other industries and to conditions in mining in other countries. Mr. Williams then considered the wage rates in the coal mining industry, the costs of production other than wages, the capital in the coal industry and its remuneration, and the output factor.

The Economics of Metalliferous Mining.

Professor Henry Louis and Mr. Hugh F. Marriott then discussed "The Economics of Metalliferous Mining." In opening they dealt with the factors involved in making a commercial success of a mining enterprise. On the credit side of the consideration were the value of the minerals produced and the accessory by-products obtained in the course of the work. Against the value of these products had to be set the cost of obtaining them. The prices obtained for the minerals were usually settled by considerations outside the power of the mining engineer to influence, but there were cases where the purity of the product determined largely the price obtained for it. The engineer's attention was mainly directed towards reductions in the cost of production. In studying this cost analysis was possible in two different ways, either in respect of the various items for which costs were incurred or in respect of the outlay upon the various services which formed part of the entire operations. In the first method the main items were wages, materials, administration and general expenses, while in the second the costs were split up under the heads of direct services such as getting, transporting and treating the ore; indirect services such as exploration and mine development; and ancillary services such as drainage and ventilation. For economy mechanical means of working had to replace, wherever possible, the use of manual labour. Generally speaking it was profitable to spend according to circumstances from 1,000*l*. to 2,000*l*. of capital if one man's work could be saved by it. The main directions in which economies could be effected were by means of underground conveyors and face loaders.

These two economic papers were discussed together, and the points brought out related to the wage problem, the arbitration system in use in Western Australia, and its efficacy in avoiding strikes, the economic necessity of a longer working day, and the unfair way in which taxation was applied in the case of metalliferous mines.

Researches on Safety Problems in Mining.

In the first part of the contribution on "Researches on Safety Problems in Mining," Sir Edward Troup described the schemes under which the work was conducted and the problems with which they were concerned. Then Sir Frederick L. Nathan dealt with the history of the use of explosives in coal mining and described some of the work so far accomplished by the Explosives in Mines Research Committee. Dr. J. S. Haldane followed with a dissertation on the main scientific questions which arise in connection with the origin of spontaneous combustion in coal. Much experimental work has been conducted on the Explosion of Firedamp and Coal-dust, and Professor H. B. Dixon and Mr. W. Mason described the leading feature of the two researches. The safe use of electricity in coal mines has been a subject of investigation for only a few years, but already results of the greatest importance have been obtained. In his contribution on the subject Mr. Robert Nelson emphasised the importance of the work done by Professor W. M. Thornton of Newcastle-on-Tyne, which had made possible the entire elimination of risks with cables and fittings, telephone and signalling apparatus. This paper also dealt with the work of Professor R. V. Wheeler and the investigation into flame-proof designs of casings for electrical apparatus conducted by Professor D. Hay and Mr. I. C. F. Statham. Mr. Nelson concluded his paper by stating that the opportunity offered for future research with the object of securing greater safety in connection with the use of electricity in coal mines was now almost non-existent. What was desirable was that the knowledge already gained should be everywhere applied.

In the discussion on these contributions exception was taken to some of the statements made by by Dr. Haldane in connection with the effects of pyrites in causing spontaneous combustion. Time did not permit much detailed reference to the research work connected with safety, but it was claimed that the reports presented on the work done justified the organisation of the congress, even though nothing else were done.

Medical Problems Associated with Mining.

When Section A met on Wednesday afternoon it was announced by Sir John Cadman that the chair would be occupied in succession by Mr. Gepp of the Australasian Institute, Dr. Wallace of the Canadian Institute, Mr. Tarleton of India, Mr. Marriott of South Africa and Mr. Humphrey Morgan, Joint President of the section. The first paper dealt with "Physiological Problems in Mining" and was prepared by Dr. J. S. Haldane. Important contributions were made to the discussion by Dr. Chapman in reference to work done by him at the Broken Hill Mines and by Dr. Irvine of South Africa. Later Dr. T. Lister Llewellyn read a paper on "Miners' Nystagmus: Its Prevention and Cure."

The Ventilation of Mines.

Mr. Robert Clive then presented a paper on the ventilation of mines, prepared by himself with Professor Douglas Hay. In this, questions relating to the resistance to air flow, to the combination of fans in series and parallel, and to the ventilation characteristics in a number of mines, were discussed.

Section B. Petroleum.

The chair was first occupied by Mr. Herbert Barringer, M.Inst.C.E., President of the Institution of Petroleum Technologists, and later by Mr. Ashley Carter.

The Economics of the Oil Industry.

In the first paper on "The Economics of the Oil Industry" Sir Robert Waley Cohen emphasised that the fluctuations in the prices of petroleum products were not due to the activities of trusts, but depended upon the general law of supply and demand. In the case of oil, supply anticipations were very uncertain, and if rises in prices were postponed until supply actually failed the dislocation in trade would be greater than when the great organisations took steps in time. Acknowledging the co-operation of Mr. Davenport, one of the authors of "Oil Trusts and Anglo-American Relations," Sir Robert distinguished six cycles in the frequently violent price oscillations since 1913, which had affected crude oil very much more than gasoline. Estimates as to the relative costs of different items in the operations were futile. The main factors promoting stability in production and distribution, rational working, and economy and research, were large organisations and the maintenance of large stocks, but the three great groups (the Royal Dutch, Shell, the Standard Oil Company,

and the Anglo-Persian-Burma group) only produced 29 per cent. of the total oil. There was no need to be alarmed about the future; the search for new fields was promising, no production field was yet completely exhausted, and, after all, each generation had to take care of itself.

Sir R. W. Cohen did not disregard the interests of the consumer in his plea for large organisations and he was complimented by Mr. Barringer and Dr. Dunstan upon his sound economic survey, which, Dr. Dunstan remarked, enabled the workers in different fields to see the forest, and not the trees only.

Petroleum Geology.

In his excellent report on "Petroleum Geology," Mr. T. Dewhurst pointed out that, in view of the extensive geographical distribution of petroleum and its occurrence in sedimentary rocks of all geological formations, from the Cambrian to the Plastocene, the mother substance of petroleum must have been in existence throughout all those ages, and favourable conditions for oil formation must repeatedly have recurred. The origin of oil was ascribed to some change of organic matter, animal or vegetable, including slow distillation of coal and lignite. The early palæozoic oil could hardly have originated from fish or coal; in many fields, but not in all, oil and coal were associated; in Burma the oil measures were rich in a molluscan fauna, which was absent in Assam. Many oil fields had evidently been deposited in inland seas or bays; the parts played by bacteria, salt, gypsum, sulphur and certain elements, found in traces in oil, were controversial. Oil might migrate far away until stopped by domes and anticlines, and finally squeezed together with gas and water into the most porous rocks. Check drilling was essential to make a good use of the initial gas pressure; geologists wanted portable deep-drilling outfits. The British Empire at present produced 1·4 per cent. of the world's oil, and the United States 72·7 per cent. But petroleum geology was still in its infancy, and the future should be viewed very broadly. Mr. Dewhurst finally showed some very interesting kinematograph films taken by a Burmese, illustrating the development of the Burma oilfields.

The discussion, by Professor Madgwick and others, concerned the importance of migration and special features. Professor H. B. Milner pointed out that geology could, at any rate, limit the possible petroleum areas, and most of the speakers advocated, with Mr. Dewhurst, the pooling of geological information. Mr. W. C. Simmons was able to announce that there were certainly indications of petroleum near Lake Albert in Uganda.

The Evolution of Oil-Well Drilling Methods.

Modern drilling methods, Mr. A. Beeby Thompson said in the first afternoon paper, were in a revolutionary stage owing to the continuous call for deeper wells and quicker means of reaching the oil sands. The old pole-tool system survived in Galicia, where depths of 5,000 ft. and 6,000 ft. had been reached in three years. The chief objections to percussion tools, still used in Baku, were fractures, due to the crystallisation of metal rods, serious accidents, and the large number of joints needed. Cable drilling was expeditious in compact, friable ground. Hydraulic percussion had been developed in California to deal with caving and casing troubles; the advantages of a mud fluid as a supporter of the walls of a well had soon been recognised; collapsing of the casing was not to be feared as long as a high fluid level was maintained. The rotary-flush attrition drill had had a revolutionary and even a disturbing influence, because it had thrown 200,000 barrels of oil and more on the market in a year. The method had its difficulties; it might give crooked holes, it was costly in power, mud and water, yet it proved economical on the whole. Core drilling had no obvious virtue except in metalliferous mining, in pilot holes, and in special cases.

Mr. Beeby Thompson supplemented his paper by many slides and by remarks on the personal factor in drilling, hours of work, centralisation and standardisation, and these remarks were as much discussed by Mr. A. Carter, Mr. Rappoport, Mr. A. E. Kitson, Mr. A. W. Nash, and others as the advantages of the rotary system and the merits of certain bits. The difficulty of finding a material of sufficient strength for rods and tools when suspended at great depths was also discussed.

Petroleum Engineering.

In his paper on "Petroleum Engineering" Mr. C. Dalley described modern improvements, which he illustrated, by permission of the Anglo-Persian Oil Company, by a very large number of plates and slides. In storage tanks, he pointed out, the ratio of oil stored per ton of steel had steadily increased. Tanks of a capacity of 50,000 tons of oil had been designed; the 10,000-ton tank, 116 ft. in diameter, 40 ft. deep, of which 200 were in commission, weighed 0·023 ton per ton of oil. To minimise evaporation, a pressure of 5 lb. per square inch was maintained in the tank; that required a special pressure and vacuum valve not depending upon corrodible springs. The units of a pipe-line pumping plant consisted of a steam turbine directly coupled with a centrifugal pump at stations 40 miles apart, operating in series. To meet the fluctuating requirements for steam and electricity in refineries, the high-pressure steam from the turbo-generator was passed into the low-pressure mains, which a reducing valve connected with the high-pressure mains, sometimes of considerable length. Traction in the refineries was affected by fireless locomotives on the steam-regeneration principle. Mr. Dalley dealt particularly also with distillation plants and washers of 50,000 gallons and cylinders provided with flat (not domed) roofs in order to reduce the space for gas accommodation.

The long-continued discussion by Mr. Carter, Mr. G. W. C. Gibson, Mr. Beeby Thompson, and Mr. A. W. Nash concerned mainly the steam-turbine drill—which is new in oil plants—the possibility of operating centrifugal pumps in series with oils, the viscosity of which would vary much with temperature, thermal efficiency, and various safety appliances.

Section C. Iron and Steel.

Section C was devoted to the subject of Iron and Steel.

Fuel Economy.

The first paper taken in Section C, Iron and Steel, at the Congress meeting on Wednesday, was on "Works Problems and Methods in Fuel Economy," by Sir Robert Hadfield. It laid stress upon the fact that the economic conditions of the present called for great efforts in the direction of fuel saving. It then gave general considerations regarding the heat balance of furnaces, dealing with heat input, heat utilisation and heat losses. Specific applications referred to heat-treatment and reheating furnaces, boilers and the open-hearth furnace. A concluding section dealt with the temperature factor in fuel economy and was illustrated by a temperature colour chart, showing the colours which correspond with temperatures ranging from 550 deg. C. up to 1,600 deg. C.

In the discussion the careful turning to account of the personal factor was emphasised as a means of obtaining fuel saving. The open-hearth furnace was said to be an apparatus difficult to work economically.

Blast Furnaces.

The second paper dealt with "Modern British Blast Furnaces," and was contributed by Mr. Fred Clements, of the Park Gate Iron and Steel Company, Limited. It stated that in the manufacture of pig iron Great Britain could rightly claim to be the pioneer country, and when Germany and America followed they were both able, not only to take up the industry at the point to which this country had brought it, but also to develop along more uniform lines. The British ore deposits differed so greatly in character that each demanded a special mode of treatment for arriving at successful results, and consequently there was practically no development in blast furnace practice for many years. This state of things, however, had not been permanent, and great attention had been paid to blast furnace design in this country during the last ten years; units were now in operation which compared favourably from an engineering point of view with those found in any country, and in some respects possessed points of superiority. When establishing a comparison from the production standpoint, it was necessary to emphasise that each plant had its own difficulties to contend with in the varying character and condition of the ore, the poverty of the ore in iron and in the varying nature of the fuel available. Mr. Clements gave an illustrated description of four different blast-furnaces, belonging to the Carnforth Hematite Company (1915), Limited, Messrs. Dorman, Long and Co., Limited, the Ebbw Vale Steel, Iron and Coal Company, Limited, and the Park Gate Iron and Steel Company, Limited. Each of these had been designed for working under dissimilar metallurgical conditions, and they well represented the present position of British blastfurnace practice.

The question of dimension and shape of the furnace was entered into by several speakers, also the size of the pieces of the material forming the charges. An advantageous size, according to the author, was 4 cub. in., but in this respect as in all other points concerning blast furnaces, a balance of conditions had to be aimed at.

Special Steels.

Dr. W. H. Hatfield read a paper on "Modern Developments in the Metallurgy of Special Steels." Referring to improvements in process of manufacture the author said that investigations had done much to explore the physical chemistry of the reactions occurring between molten steel and steel-making slags, leading to a satisfactorily refined and purified steel. The ultimate reliability of the product largely depended, however, upon the subsequent methods of casting and manufacturing the steel. Here Dr. Hatfield emphasised the different behaviour of the steel when cast in small ingots and in large ones; the larger the ingot, the more important were the questions of segregation and complete ingot soundness. It would be well, he added, that engineers should learn that it was much safer to build up a part of smaller masses than to push the ability of the steel-works, as regards the production of the largest masses, to the fullest extent. One of the most important of the processes relating to large masses was that of hardening and tempering. Dr. Hatfield then reviewed the manufacture of steel alloys, and their application for a number of mechanical purposes. He instanced the manufacture of springs for automobiles; this had led to the search for steels which, with considerable hardness (about 400 Brinell), could be obtained of ductility sufficient to prevent fracture under occasional abnormal stresses. The steels now used in the hardened and tempered condition, such as manganese-silicon steel and chrome-vanadium steel, particularly the latter fully met the conditions. The developments in the metallurgy of special steels encouraged the hope that civil engineers would see that they were employed to a much greater extent in future. One extremely important development in the last few years had been the solution of the problem of rust resistance, in the shape of stainless steel containing 12 to 14 per cent. of chromium. Dr. Hatfield stated that the metallurgical investigator had tackled with considerable success the production of more reliable and effective permanent magnets, also of steel highly resistant to wear and high-speed tool steel, among others. He concluded by stating that a more intimate knowledge of the properties of the steel from the designer's standpoint was probably the most important direction where progress had taken place of recent years. He instanced the study of the effect of repeatedly applied stresses, fatigue tests, hammer tests.

In the discussion more complete co-operation than now obtained was advocated between the engineer and designer, and the metallurgist and steelmaker. It, nevertheless, remained a fact that large steel ingots would still be required, and it was the duty of the steelmaker to provide them. Endeavours should be made to lower still further the sulphur and phosphorus, but the pressure of non-metallic inclusions was perhaps as harmful as these two elements. Due discrimination should be exercised in regard to ghost lines, since some varieties of these need not at all lead to rejection.

Alloy Steels.

The fifth paper taken was a contribution by Sir Robert Hadfield, on "The Development of Alloy Steels." It referred to the author's manganese

steel, silicon steel and other ferrous alloys, and drew attention to the benefits these alloys had conferred generally by their resistance to wear, to heat, or to corrosion, or again by their electrical properties, thus making for a decrease in consumption of the still available mineral resources of the world. Further research was showing that the possibilities of alloy steels were as yet exploited very incompletely, the total field was of enormous extent and by far the greater part of it was still unexplored.

Special emphasis was laid in the discussion upon the necessity of users of special alloy steels considering these as finished articles as they came from the steelmaker. The users must not heat-treat them in any way, otherwise trouble would be experienced.

Railway Steels.

The last paper taken on Wednesday was an interesting contribution by Mr. E. H. Saniter, on "Railway Steels." It opened with a table giving the production of forgings, railway material, &c. in Great Britain for the five years from 1919 to 1923. Export figures of railway material from Great Britain, were also quoted for the five years 1913 and 1920 to 1923, the two tables combined showing that an adequate supply was available when the demand came. Our railway materials, according to their class, were made either by the acid open-hearth furnace, the acid Bessemer process or the basic open-hearth furnace. The three processes were briefly described. Dealing with a few railway specialities, Mr. Saniter stated that the highest class of tyres were all made of acid open-hearth steel, whilst wagon tyres were sometimes made of acid Bessemer or basic open-hearth steel. The safety of the tyre was ensured by drop test and tensile test, the latter varying from 45 tons to 75 tons per square inch. In order further to ensure safety, it was customary to heat-treat the tyres of higher tensile strengths. Crank axles were invariably made of acid open-hearth steel of the best quality; they were normalised or oil-treated, and their quality was controlled by analysis, tensile and cold-bending tests. The best class of straight axles were of acid open-hearth steel, but where the work required was not so severe, acid Bessemer and basic open-hearth steel were sometimes used. The great bulk of railway and tramway rails and fishplates were made of basic open-hearth and acid Bessemer steel; the quality was controlled by analysis, tensile and drop tests. The paper gave a list of British Standard Specifications relating to railway steels, adding that these specifications had been prepared with great care to ensure that the material supplied under them shall be of the required quality; the standard set was a high one.

Attention was called in the discussion to the remarks made earlier in the day as to elimination of sulphur by phosphorus. Mr. Saniter had said that the basic open-hearth process eliminated these elements, and that it was not necessary to start from pure materials. The process was, therefore, one to be highly recommended from that point of view. It was nevertheless agreed that the acid open-hearth furnace produced the purest, most reliable and most regular steel, a fact which should be widely made known throughout the Empire.

Section D—Non-Ferrous Metals.

Professor T. Turner occupied the chair, when the section met at 10.30 a.m. on Wednesday.

Aluminium Alloys.

The first paper taken dealt with "Light Alloys of Aluminium," and had as its authors Dr. W. Rosenhain and Mr. S. L. Archbutt. We commence reprinting this paper on page 750 of this issue and may therefore proceed at once to the discussion.

The discussion on the paper was opened by Colonel Belaiew, who said that although he was specially interested in steel he recognised that there were circumstances in which he would favour the lighter alloys, and he thought that if used under proper conditions they could be depended upon. Steel itself was of course subject to corrosion. The authors had compared the specific tenacity of these alloys with mild steel. He would like to know how they compared in this regard with the special steels. In certain uses the question of cost hardly arose, and in those cases the light alloys would have to compete with these special steels rather than with the mild quality.

Dr. Moore, of Woolwich, followed and said that, great as had been the directly practical value of the metallurgical work done at Teddington this was, he thought, exceeded by the value of the constitutional studies also made there. These had opened up possibilities of further developments, and the results as to the nature of "age hardening" were of prior importance. This phenomena had been discovered at Woolwich prior to its recognition in Germany, but the facts had not been published. It was first noticed in an alloy consisting of aluminium and about 10 per cent. of zinc. The Brinell hardness of this was measured, but when it was sought later on to confirm the figure found, it turned out that the Brinell number had doubled in the interval. This led to further experiment, which showed that other alloys also possessed the property of age hardening. The aluminium magnesium alloys then tested at Woolwich did not however show it. It was not realised at that time that the property was due to silicon, and the aluminium used did not contain sufficient of this element to get age hardening in the magnesium alloy. He thought that the caution of engineers in adopting the new light alloys was based on ignorance.

Mr. Archbutt said that a large part of the paper was based on the "constitutional" researches carried out at the National Physical Laboratory.

In closing the discussion Professor Turner said that these constitutional studies were practicable only at places like the National Physical Laboratory. They required great patience, much skill and elaborate apparatus. Some of the annealings had to be continued for weeks, and months might be required to investigate a single small area of the equilibrium diagram. From one point of view work of this kind might be regarded as unproductive and uninteresting, but from another aspect it was of fundamental importance.

In reply, Dr. Rosenhain said that the paper was really based on team work. A long path had had to be pursued, but the study had justified itself even from the practical standpoint. They were now attempting at the National Physical Laboratory a similar fundamental inquiry into steel and had already reached some very striking results. As regard specific tenacity, if special steels were used in the hardened condition, in which they had a strength of about 100 tons per square inch, the specific tenacity was about the same as those of the best light alloys. The latter having, however, three times the bulk for a given weight, could be used where it would be impossible to use steel, of the same weight, as the latter would be too thin to be practically available. For combined ductility and tenacity the light alloys were superior to any steel. Light alloy connecting rods were being used in aero-engines of the same dimensions as the steel stampings previously employed.

The Copper, Brass and Nickel Industries.

The second paper taken on Wednesday morning dealt with "The Economics of the Copper, Brass and Nickel-silver Industries in 1924." It was read by its author, Mr. George W. Mullins, M.B.E., M.Inst.Met., who stated that in the past it had proved impossible to force up prices of the metals named in his title above a certain limit; in part because substitutes were available and in part because of the return of scrap to the market. In one case in which the price of copper was carried up to 120*l.* per ton the movement was broken by hundreds of tons of scrap coming back from China. The fact that brass scrap could be so easily worked up favoured, he said, the small establishment, and before the war we had in consequence over-production and inadequately developed plants. The war enormously increased the demand both for quantity and quality, and in the years immediately succeeding the price of copper rose to 137*l.* per ton. Wages remained high and output very small. As the result production fell to one-fourth of the works' capacity. Since then American producers had reduced copper prices to some 68*l.* to 78*l.* per ton, which corresponded to, say, 43*l.* to 50*l.* in pre-war times. Wages had come down and output per head gone up. The higher standard of quality attained during the war has been maintained, the good scrap available helping towards this end.

The discussion on this paper was opened by Mr. Gepp, who said that he thought the great improvement which had been made in the purity of commercial zinc should make it easier for manufacturers of alloys to maintain a high quality. In the old days the purity of the zinc varied enormously, but the Australian zinc now supplied assayed 99·9 per cent., and the uniformity was such that the maximum difference in the analysis of the thousands of tons of slabs produced at Hobart did not exceed 0·05. He thought there was room for the development of other alloys. The addition of a very small percentage of cadmium to copper trolley wires, for example, had increased the life at curves fourfold, and without materially affecting the conductivity.

Mr. W. A. Barkley said that the war had raised the quality of the output in the metallurgical industries, and customers were now demanding better material. Much scrap was produced in the works themselves, and here he thought great economies were possible. Scrap, moreover, could not be melted again and again without leading to deterioration in the product.

In reply, Mr. Mullins agreed that the salvation of the trade was to be found in reducing scrap and maintaining high quality.

(To be continued.)

METAL PRICE DIAGRAMS.

In the diagrams on page 743 the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

The Association of Consulting Engineers.—We are informed that Mr. Sidney R. Lowcock, of 6, Queen Anne's Gate, S.W. 1, has been elected Chairman of the Committee of the above Association for the ensuing year.

Kelvin Centenary Celebrations.—To commemorate the centenary of the birth of Kelvin several interesting functions have been arranged by the Kelvin Centenary Committee for July 10 and 11. At 4.30 on the afternoon of the 10th, at the Institution of Civil Engineers, Great George-street, Westminster, the presentation of the Kelvin Medal will be made to Dr. Elihu Thomson (U.S.A.), Sir Charles Morgan, President of the Institution, being in the chair. This will be followed immediately by the Reception of Written Addresses from the scientific societies of the British Dominions and foreign countries. The Kelvin Oration will then be delivered (about 5 o'clock) by Sir J. J. Thomson. Sir Richard Glazebrook will preside at the Reception of Addresses and at the Kelvin Oration. In the same building there will be available for the inspection of visitors an exhibit of Kelvin experimental apparatus which has been collected by the committee specially for this commemoration. These exhibits will be on view from July 8. An important feature of the celebrations will be a banquet to take place on the evening of Friday, July 11, at the Connaught Rooms, Great Queen-street, London, W.C.2., when the Right Hon. Earl of Balfour, K.G., O.M., F.R.S., will preside. Many distinguished scientists and engineers, among them delegates from the societies of Great Britain and the Dominions, as well as the continent of Europe and the United States, have already indicated their intention to be present. Those who wish to attend the banquet should send in their application for tickets (price two guineas each inclusive of wines), to Mr. D. N. Dunlop, Hon. Secretary of the Kelvin Centenary Committee, 61 and 62, Lincoln's Inn Fields, London, W.C.2.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

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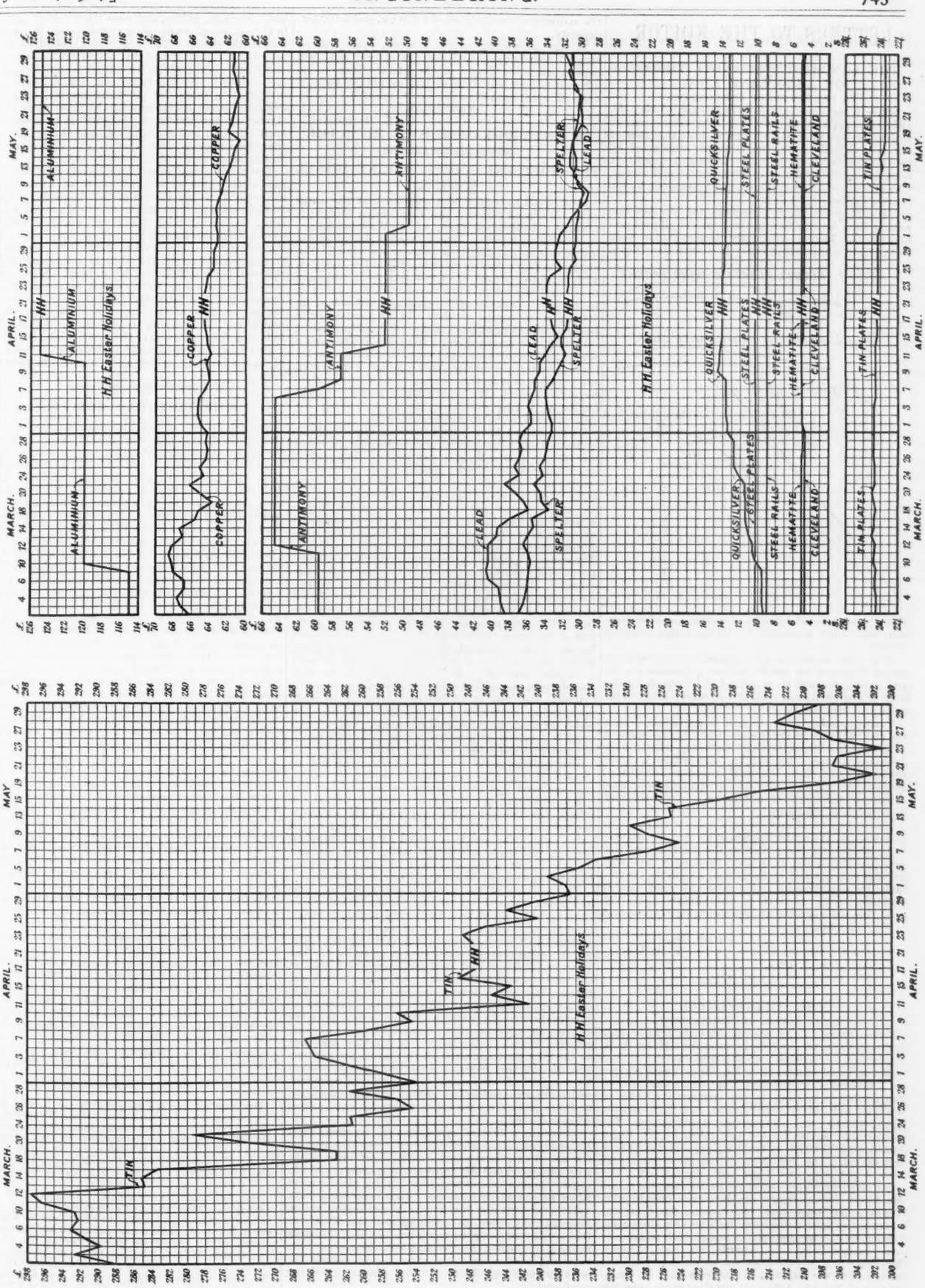


LETTERS TO THE EDITOR.

THE LANCHESTER-PRANDTL THEORY OF AEROPLANE LIFT.

To the Editor of Engineering.

SIR,—In the *Zeitschrift für Flugtechnik*, of May 26, 1924, there appears an article by A. Betz on an extension of Joukowsky's method to wings of finite thickness at the tail tip. The extension is simply illustrated by the transformation of concentric circles and equidistant rays, having the origin as common centre and vertex, into a family of confocal ellipses and hyperbolas, by the transformation $w = z + z^{-1}$.

The unit circle $|z| = 1$ becomes the straight line joining the common foci of the confocal ellipses and hyperbolas. Taking a slightly larger radius than unity, the corresponding curve is a very flat ellipse.

Fig. 1. ACTUAL ALBATROS WING PROFILE.

Fig. 2. ADJACENT PROFILE WITH CUSP.

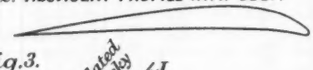
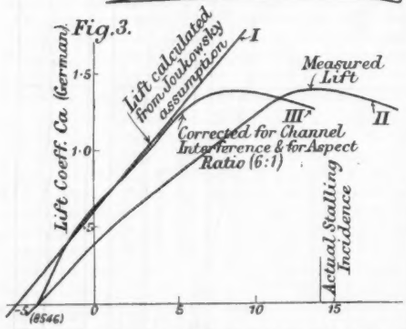


Fig. 3.



Thus the mechanical difficulty of making an indefinitely thin sharp plate is avoided by taking a thin elliptical section.

In a quite analogous way, taking a circle with its centre displaced by small positive quantities dx, dy and passing through the point (–1,0) we obtain by the same transformation a typical Joukowsky profile with a cusp at the tail tip.

Taking as before a very slightly larger radius, so that the point (–1,0) is just enclosed, we get what is in effect a consecutive curve closely following the former Joukowsky profile but having everywhere a finite thickness and a finite radius of curvature at the tail. It should be remarked that the circulation is now to be chosen so that the deadwater point is at the point of least radius of curvature.

This extension of Joukowsky's transformation is so obvious that the writer applied it to an "Albatross" wing profile in a paper read to the Air Congress last year (see Figs. 1 and 2), without thinking it necessary to enter into detailed explanations. Applying the formulæ for correcting for aspect ratio and wind channel wall interference, as given in ENGINEERING (page 171 *ante*), the close agreement over the flying range shown in Fig. 3 is obtained.

I am, &c.,
A. R. LOW.

London, June 3, 1924.

"THE TRANSVERTER."

To the Editor of Engineering.

SIR,—Owing to my absence abroad, I have only just seen the letters in ENGINEERING from Major A. M. Taylor and "Chartered" on this subject.

Major Taylor quotes from Mr. Roger Smith's paper on "Railway Electrification," but omits that part of the quotation relating to the comparative costs of 3-phase and rotary transmission and high tension direct-current and transverter transmission. The comparative figures for the case taken by Mr. Roger Smith were 730,000*l.* in the first case and 355,000*l.* in the second. The line losses at maximum peak load were 4 per cent. and 3 per cent. respectively. The costs given by Major Taylor are purely imaginary, and Mr. Roger Smith's figures are the correct ones to take. There is no doubt that high-tension direct current offers many advantages over high-tension alternating current for the transmission of power, both technically and commercially. As regards the size of unit, Mr. Roger Smith chose 2,000 kw. as the most generally suitable unit for railway sub-station work. An examination of English, American and Continental practice will show that this size of unit is seldom exceeded and the majority of the units are of 1,000 kw. and 1,500 kw. capacity.

In any alternating-current system, there will be step-up transformers, and the size of unit used will depend upon the design of the plant. There is no inherent reason why transverters cannot be built in units of equal capacity.

Your faithfully,
W. E. HIGHFIELD.

36, Victoria-street, London, S.W.1, May 29, 1924.

THE WALLSEND-SULZER MARINE DIESEL ENGINE.

SHOP trials have just been completed at the works of the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, of a Wallsend-Sulzer, two-stroke air injection type of marine Diesel engine which will be installed in a single-screw vessel. The engine has four cylinders 680 mm. (26¾ in.) in diameter, with a piston stroke of 1,200 mm. (47¼ in.), and develops 1,800 b.h.p. when running at 90 r.p.m.; it is, however, capable of developing 2,000 b.h.p. at 100 r.p.m. in regular service. An air compressor, a bearing lubricating oil pump and a crosshead lubricating oil pump, are driven directly from the engine, and a scavenging air blower, and two pumps for the jacket cooling water and piston cooling water respectively, are required as independent auxiliaries when the main engine is running. We hope to deal more fully with the engine at a later date, but, in the meantime, the particulars given below will be of interest.

The cylinders have interchangeable liners and the cylinder jackets and liners are both constructed of special cast iron and are water cooled. The cooling space between the cylinder jacket and liner is rendered easily accessible by hand holes. The water enters the cooling jackets at the bottom and leaves it at the top at the highest point. The bottom of the liner is a water-tight fit in the jacket, but the arrangement allows of free expansion in the direction of the axis. Forced lubrication is provided for the working cylinders. The exhaust gases leave the cylinder through exhaust ports, and the scavenging air is introduced through separate scavenging ports. The latter are in two rows near the bottom of the cylinder, and are situated opposite the exhaust ports, of which there is only one row. The opening and closing of the exhaust ports and of the lower row of scavenging ports are effected by the piston. Through the upper row of scavenging ports, which are not closed by the rising piston until a certain time after the exhaust ports have been closed, an additional charge of air is supplied to the cylinder, the time at which the upper row of ports open being controlled by automatic valves. The metal between the individual scavenging and exhaust ports is provided with water passages, through which water circulates for the purpose of cooling them.

The cylinder head for this engine, it should be mentioned, has only one central opening for taking the combined fuel and starting valves, and the fuel valve, two starting valves (one arranged behind the other), the cylinder safety valve and the indicator connection are arranged in one common water-cooled valve cage. The piston is cooled by water supplied through telescopic tubes, the water being injected into the piston cooling space as a free jet, and flowing back freely to open funnels fitted outside the frames.

The working of the valves is controlled by cams and levers, a double set of cams for ahead and astern running being fitted on a horizontal camshaft driven from the main shaft by means of worm wheels and a vertical shaft on the flywheel end of the engine. The worm gearing is enclosed and runs in an oil bath. The valve levers are of cast steel and carry short links at the ends to which the ahead and astern rollers are fitted. The valve levers are pivoted eccentrically on a lever shaft which can be rotated. This shaft is rotated first to the starting position, which puts the starting air valves in action. Afterwards to the working position which puts the fuel valves in action, and then to the stop position, when all the valves are cut out. For effecting this operation a starting machine worked by compressed air is employed. All the cylinders, which are arranged in two groups, are started on air, and one group after the other is changed over to fuel when starting up.

Reversing is effected by rotating the reversing shaft by means of a hand wheel and worm gear, thus moving the ahead or astern rollers on the short links of the valve levers on to their corresponding cams; a blocking device prevents reversing from taking place, except when the valves are in the "Stop" position. The valve gear puts the fuel pump in and out of action automatically when manœuvring, and the lift of the fuel needle can easily be regulated for ahead or astern running by turning the reversing shaft by means of the reversing hand wheel; the arrangement ensures the advance opening of the needles always remaining unaltered.

All the main bearings of the engine, crank and crosshead bearings, guides, and also the rubbing surfaces in the engine and compressor cylinders, are fitted with forced lubrication. The engine is enclosed so as to be oiltight, and all the oil that drains down is collected under the crankshaft in an oiltight sump formed in the bedplate. At the front end, the engine has a reciprocating pump for oil circulation driven by an overhung crank on the end of the main shaft. One three-stage compressor, of the vertical type, supplies both injection and starting air, and the capacity of the compressor is such that it can deliver nearly double the quantity of air actually required.

The trials above referred to included a non-stop run of 60 hours at the full power of 1,800 b.h.p., the revolutions per minute of the engine being about 90 lb. and the oil fuel consumption 0·378 lb. per b.h.p.-hour. A further trial of 6 hours' duration with an overload of 10 per cent., making the total brake horse-power developed about 2,000, was also carried through satisfactorily, the oil fuel consumption during this trial being 0·38 lb. per b.h.p.-hour. Starting and reversing operations were carried out, and a slow-running test also formed part of the trial conditions; the performance of the engine in these respects, we understand, left nothing to be desired. Immediately following the conclusion of the power trials, the engine casing doors were opened and a close examination made of all the bearings, which were found to be perfectly cool.

THE BIRTHDAY HONOURS.

The official list of the Birthday Honours contains the names of very few men directly connected with the engineering profession. We note that knighthoods have been bestowed upon Mr. R. L. Wedgwood, C.B., C.M.G., the General Manager of the London & North Eastern Railway, and upon William Galloway, D.Sc. In the Civil Division Engineer Rear-Admiral W. M. Whayman, C.B.E., receives a Companionship of the Order of the Bath, while in the Military Division a like distinction has been conferred upon Colonel C. W. Singer, C.M.G., D.S.O., Chief Engineer, Egypt. In the Civil Division Mr. R. A. Dalzell, C.B.E., Director of Telegraphs and Telephones, G.P.O., receives a Companionship of the Bath, an honour which is also given to Mr. A. E. Faulkner, C.B.E., Director of Sea Transport of the Board of Trade. The Colonial List shows that a C.B.E. has been given to Lieut.-Colonel J. R. Tainsh, Director of Railways, Iraq, and that Membership of the Order of the British Empire has been conferred upon Mr. W. J. Bramwell, lately Telegraph Engineer, Post and Telegraph Department, Gold Coast. We observe that Viscount Inchcape is the recipient of a Grand Commandership of the Order of the Star of India, and a Companionship of the same Order has been given to Mr. William Sutherland, V.D., Chief Engineer, Telegraphs.

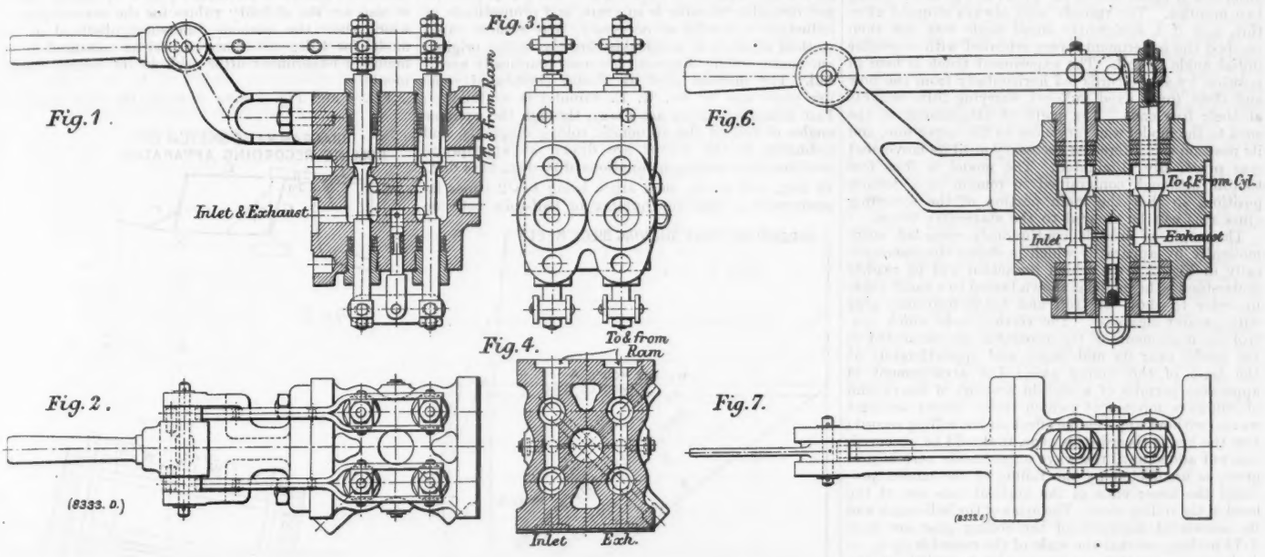
In the Military Division of the Order of the British Empire, a Commandership of the Order has been conferred upon Engineer Rear-Admiral F. W. Marshall, while Engineer Commander F. Robinson receives an O.B.E. Captain P. K. Boulnois, R.E., is also a recipient of an O.B.E. Among the Civil Awards of the B.E. Orders are a C.B.E. to Mr. C. H. Bressey, O.B.E., F.S.I., Chief Engineer, Roads Department, Ministry of Transport, and another to Mr. H. E. Oakley, O.B.E., Deputy Director of Works and Buildings, Air Ministry, while an O.B.E. has been conferred upon Major John S. Buchanan, Senior Assistant, Directorate of Research, Air Ministry, and Mr. C. L. Fielder, M.B.E., Civil Engineer-in-Chief's Department, Admiralty; Mr. Evan Ortner, Superintendent of the Technical Schools, Woolwich Arsenal, and Mr. R. McKinnon Wood, Principal Technical Assistant, Farnborough Air Factory, receive an M.B.E. Among the Indian Awards we notice an O.B.E. for Mr. Conrad A. Cooke, Chief Engineer, Bombay, Baroda, &c., Railway, and another for Mr. F. Walford, Principal of the School of Engineering, Bihar and Orissa. Mr. W. H. Murphy, Executive Engineer to the Municipal Commission, Civil and Military Station, Bangalore, received an M.B.E.

THE ROBERT BLAIR FELLOWSHIPS.—A booklet giving full particulars of the Robert Blair Fellowships in Applied Science and Technology offered by the London County Council has just been issued by that body, and is obtainable from the Education Officer, County Hall, S.E.1. We explained the proposals in connection with these fellowships in our issue of March 7 last on page 311.

THE CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—After acting as Vice-Principal of this school for nearly twenty-six years and as Principal for a similar period, Mr. J. W. Wilson has announced his intention of retiring at the end of the present term. His brother, Mr. Maurice Wilson, who has been the Vice-Principal for twenty-six years, will now succeed him in the Principalship. The school, we may mention, was founded by Mr. Wilson, Senior, in 1872, and over 1,300 engineers have been trained there.

"HOMEYARD" HYDRAULIC VALVES AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. GLENFIELD AND KENNEDY, LIMITED, ENGINEERS, KILMARNOCK.



"HOMEYARD" HYDRAULIC VALVES.

THE difficulty of securing a really satisfactory valve for high pressures has often limited the pressure which it has been thought advisable to use in hydraulic work. In Figs. 1 to 7 on this page we illustrate a form of valve evolved by Messrs. Glenfield and Kennedy, Limited, of Kilmarnock, of which examples are to be seen at the British Empire Exhibition, and which are used for pressures up to 3,500 lb. per square inch. The control is so effective that in the smaller sizes force applied by a finger and thumb is quite sufficient to work the valve under pressures of 1,000 lb. per square inch. Figs. 1 to 5 show the double ported valve, while Figs. 6 and 7 illustrate the single ported pattern. The construction will best be followed in Fig. 6 which shows the simpler valve of the two. As will be seen there are two balanced valves in the mounting, one controlling the inlet and the other the exhaust. The inlet and exhaust connections are below the valves and combine above for one connection to the hydraulic machine cylinder. The two valves have each a crosshead at their upper ends, pivoted in the fork of a lever. Between the two crossheads centres is a pin from which hang two links passing down outside the body of the valve to its underside, where they are coupled to a crosshead forming part of a small plunger working in a hole bored in the body casting. Inlet pressure is always exerted on the upper side of this plunger, which therefore tends to pull the links downwards, keeping the two valves closed.

Attached to the body is a bracket at the end of which is pivoted a cam provided with a handle. The cam is recessed on the side nearest the valve, and in this recess is housed the rounded end of the long valve lever. On the handle of the cam being raised or lowered the valve lever is correspondingly depressed or lifted, the exhaust valve being operated in the first case and the inlet in the second. The return of the handle to mid position closes both valves, while one or the other can be indefinitely held in the open position by turning the handle so far that the valve lever rests on the circular rim of the cam. Various modifications of the lever and cam are possible to suit different situations.

The valve just described is suitable only for admitting and exhausting pressure to a single-acting cylinder. To meet the very common conditions under which double-acting machines have to be controlled, and pressure supplied to either end of a double-acting cylinder, or either of two single-acting cylinders, concurrently exhausting from the other end or cylinder, the double ported valve shown in Figs. 1 to 5 is employed. In this the actual mechanism is similar to that described above, but the valves and valve levers are duplicated, all, however, being under the control of one cam and handle. The passages in the body are cross-connected and the bottom ends of the balanced valves project beyond the body to be coupled, in pairs as shown, by links to the small plunger crosshead. The arrangement provides that on pressure being admitted to one side of a piston or to one cylinder, the other side or other cylinder is opened to the exhaust, the handle being either lifted or lowered according to the requirements of the moment.

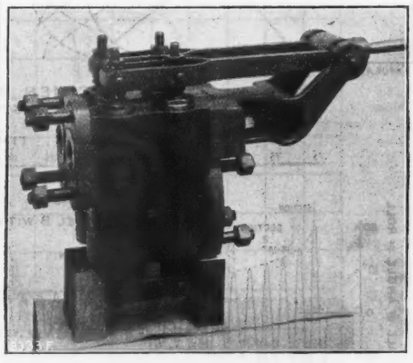


FIG. 5.

We may say that single ported "Homeyard" valves are manufactured by Messrs. Glenfield and Kennedy in nine sizes, the smallest of which gives a ¼-in. waterway and the largest one of 4 in. Double ported valves are only made up to 2 in.

RESULTS OF SOME ROLLING EXPERIMENTS ON SHIP MODELS.*

By M. P. PAYNE, R.C.N.C.

THE principal object of the experiments was to compare the behaviour of the bulged and unbulged forms of vessels of the Royal Sovereign class as regards rolling, &c. As is generally known, the vessels were originally unbulged (*vide* Sir Eustace d'Eyncourt's paper, "Naval Construction during the War," Transactions of the Institution of Naval Architects, vol. lxi), and they were equipped with rather large bilge keels, in consequence of which, also on account of their moderate metacentric height, they proved excellent ships as regards rolling in a seaway. When some of the vessels were fitted with a bulge it was decided to omit the bilge keels, partly from docking and partly from speed considerations, it being anticipated (as the experiments proved) that the new naked underwater form would offer more resistance to rolling than the original, and in part at least compensate for the omission of the bilge keels. Although this plan was to a considerable extent successful, it appeared, after a few years' experience with these vessels, that the decrease in rolling period which accompanied the increased metacentric height of the bulged forms, associated as it was with a lower resistance to rolling than that of the unbulged forms fitted with bilge keels, caused them on occasions to roll to larger angles than the unbulged prototype. An example taken from a report of the Commander-in-Chief of the Atlantic Fleet gives the angle of maximum roll for two bulged ships as 12½ deg. to 15 deg. each way, and of the unbulged on the same occasion as about 8 deg. each way.

This suggested the desirability of fitting bilge keels to minimise the amplitude of roll, and recourse was had to model experiments in order to put the bulged ships on a par with the others as regards resistance to rolling. It will be recalled by many that attempts to omit bilge keels have been made before, notably in the case of the old Royal Sovereign class,* which vessels, although they proved generally good sea boats, did on occasions roll heavily, so that bilge keels were subsequently fitted, with advantage to their sea behaviour.

The relevant particulars for the rolling experiments (these apply to the ship deep, to which corresponding condition the experiments were confined), together with the designation of the models, are as follows :—

TABLE I.

Form.	Model Designation.	Mean Draught.	Displacement (Tons.)	G.M. (Ft.)	Prescribed Rolling Period (secs.).
		Ft. in.			
Royal Sovereign (unbulged) ..	A	33 0	30,600	3·4	19
Royal Oak (bulged) ..	B	31 6	33,240	5·2	16
Revenge (bulged)	C	31 6	32,000	5·2	16

The models were made of paraffin as usual, their scale being one-fortieth full size. Apart from bilge keels, the models were in all cases naked. A midship section of each form is shown in Fig. 1.

The experiments may conveniently be divided into four groups :—

(*a*) Ordinary still water rolling or extinction experiments.
(*b*) Experiments to determine the effect of motion ahead on rolling.
(*c*) Rolling experiments amongst waves.
(*d*) Bilge keel resistance and vane experiments.

(*a*) STILL-WATER ROLLING EXPERIMENTS.

Method of Conducting the Experiments.—The model is placed at an angle of 45 deg. across the tank, near its mid-length, and the experiment truck brought over the model. The position of the model in the tank is

* Paper, abridged, read at the Spring Meeting of the Institution of Naval Architects, April 10, 1924.

* Trans. I.N.A., vol. xxxvi, "Notes on Further Experiments with First-Class Battleships," by Sir William White.

chosen in order to minimise the confusion of the record by recoil waves from the ends of the tank. In theory this should allow a time of a little more than one and a half minutes from starting the roll, but as far as observation could detect the interval was more nearly two minutes. The records were always stopped after this, and if a sufficiently small angle was not then reached the experiments were repeated with a smaller initial angle of roll. The experiment truck is held in position by single cords led horizontally from the bow and stern (over fixed pulleys), carrying 5-lb. weights at their free ends. The point of attachment of the cord to the model was very close to the water-line, and its position was altered as necessary until its movement was practically eliminated. The model is thus free to roll, although constrained to remain in a definite position, so that the main portion of the recording apparatus can be secured to the stationary truck.

The angle of heel is continuously recorded automatically by apparatus which is shown diagrammatically in Fig. 2, from which its action will be readily understood—the model is shown heeled to a small angle in order to show the roll and heave-recording gear with greater clearness. The vertical rods which control the movements of the apparatus are connected to the model near its mid-length and approximately at the level of the rolling axis. The arrangement of apparatus permits of a certain amount of heave and of sideways movement (which latter occurs amongst waves) without appreciable effect on the rolling record; also the heave record (this gear, it should be observed, was not added until the wave experiments were in progress) is unaffected by the rolling of the model, provided the lower ends of the vertical rods are at the level of the rolling axis. The arms of the bell-crank and its associated members of the rolling gear are each 5·73 in. long, so that the scale of the record is $\frac{1}{10}$ in. = 1 degree inclination; time is also recorded on the cylinder by the usual means. Two specimens of the automatic records (referred to as rolling diagrams) are shown in Fig. 3. This apparatus was made some years ago by Mr. R. E. Froude, who before accepting it as satisfactory made experiments to demonstrate that it complied with an obviously essential condition, *i.e.*, that its resistance was not likely sensibly to affect the motion of the model. It was found that the resisting moment on the model due to the recording apparatus was 0·0092 in.-lb., and with a naked model similar to those at present under consideration, but possessing a very small extinction (actually 1 degree in fourteen rolls at a mean extreme angle of roll of about 3 deg.), this was found to affect the results obtained only to the extent of about 1½ per cent. Thus the apparatus is amply delicate for these experiments, although probably none too sensitive for testing the relative merits of minor differences of section in a naked model.

The roll of the model is worked up by hand, all possible care being taken to avoid giving to the model motion of any other description. The apparatus does not permit of angles of roll being recorded if they exceed about 22 deg., and generally 20 deg. is regarded as the working maximum. Even at 20 deg. some departure obtains from ship conditions in the topside arrangements of the model, the after freeboard of which is sufficient to keep the deck edge out of water in the model, though not completely so in the ship. All three models were tried, with and without bilge keels, these being arranged to be readily removable. Particulars for the various bilge keels are as follows:—

TABLE II.

Ship.	Model.	Approximate Length of Keels.	Depth of Keels.	Area of Diagonal Plane.
		Ft.	Ft.	Sq. Ft.
Royal Sovereign (unbulged form) ..	A2	350	3–4	1,274
Royal Oak (bulged form)	B2	200	3–3½	681
Revenge (bulged form) .. .	C2	200	3½	700

The position of the bilge keels is indicated on the midship section for each form. The models were each fitted with a portable wooden frame, which enables ballast to be stowed at two different levels, each well above the bottom of the model. This permits of a range of rolling periods to be obtained covering those corresponding to the ships. The extinction is, of course, quite sensitive to period, and the experiments embraced a range of periods of 2·3 to 3·05 seconds for the unbulged model A, and 2·35 to 2·75 seconds for the bulged models B and C, the prescribed periods being 3·005 seconds (corresponding to 19 seconds) and 2·53 seconds (corresponding to 16 seconds) respectively.

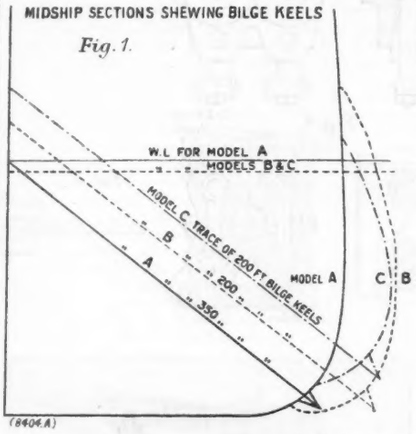
The general method of analysis of ship still-water rolling trials, namely, to evaluate the extinction $\frac{-d\theta}{dn}$ by differentiation of the curve of declining angles is not sufficiently expeditious for model work. With the models the number of experiments which it is possible and desirable to make is so great, and promptitude in reduction of results so necessary, that a more rapid method of analysis applicable directly to the original automatic rolling diagrams becomes practically essential. The method used at Haslar (instituted some ten years ago by Mr. R. E. Froude) is as follows: Fair bounding curves are drawn through the extreme angles of roll on the automatic rolling diagrams, and ordinates to the curves are drawn at appropriate positions representing inclinations of 20 deg., 14·4 deg., 10 deg., and so on, each angle being $1/\sqrt{2}$ times its predecessor; then the number of half-rolls between these successive angles (which intervals are referred to as sections, *i.e.*, 20 deg. to 14·14 is section 1, 14·14 deg. to 10 deg. is section 2, . . ., 1·77 deg. to 1·25 deg. is section 8, and 1·25 deg. to 0·885 deg. is section 9—the last) is read off (accurately in decimals). The number of rolls in any section represents "freedom of rolling" or defect of extinction, it is referred to as the freedom coefficient for that section, and the comparisons of the different forms are made on the basis of these freedom coefficients.

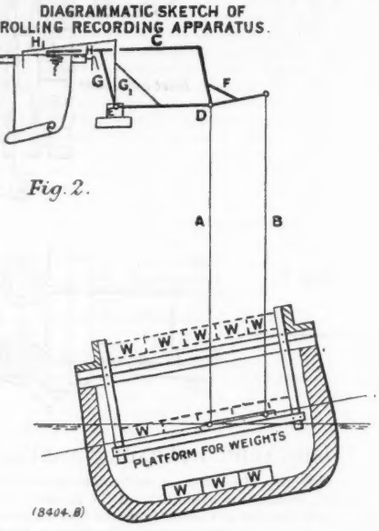
In ballasting the model to any specified period, it is not readily possible so to dispose the ballast that the model will roll at that period with the corresponding reputed ship metacentric height. Every effort was made to ensure that at the prescribed period the model approximated as closely as practicable to the (corresponding) GM., but for the other periods a different GM. had to be accepted. The freedom coefficients as plotted, however, have been corrected by the ratio of the reputed standard stability to the stability of the experiment, so that they apply to the model with the standard GM. at the period of experiment.

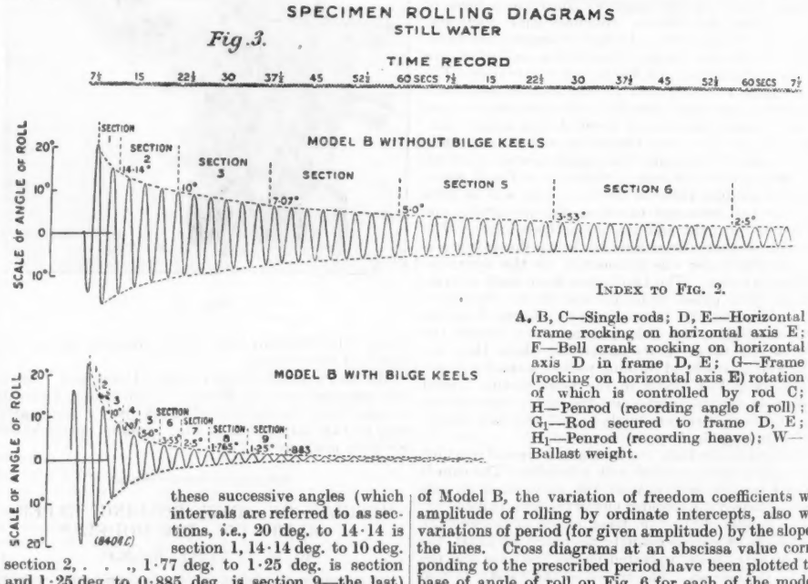
The freedom coefficients, corrected to the standard stability, are shown for one of the models (viz. B) plotted to a base of period for the several section limits 1 to 9 in Fig. 4 and Fig. 5. The period base represents actually the mean period for the last four sections, *i.e.*, 3·54 deg. to 0·885 deg., the mean period for the first three sections (*i.e.*, 20 deg. to 7·07 deg.) being indicated by bracketed lines for each period. The successive spots of each section belonging to the successive grades of period are joined by straight lines, as also are the stability values for the several grades which show the moment differences observed in the model for 4 deg. difference of heel as measured by an inclining experiment after each set of rolling experiments.

Fig. 4 and Fig. 5 show directly, for each condition of Model B, the variation of freedom coefficients with amplitude of rolling by ordinate intercepts, also with variations of period (for given amplitude) by the slope of the lines. Cross diagrams at an abscissa value corresponding to the prescribed period have been plotted to a base of angle of roll on Fig. 6 for each of the models, the base scale representing a mean proportional between the limiting angles of the section, *i.e.*, the ordinate at, say, 8·41 deg. represents the freedom coefficient for the section 10 deg. — 7·07 deg. The successive spots are here also connected by straight lines; curves would have been preferable in both cases, but the variation of freedom coefficients with period seemed too irregular for reliable curves to have been drawn without closer period gradations and to more experiments at each of them than the circumstances appeared to warrant.

The results show that the freedom coefficients are very sensitive to period, and that with the unbulged model there is a general tendency for the freedom to increase with period, as theory would lead one to expect. Both the naked bulged models, however, appear to have a minimum freedom coefficient (*i.e.*, a maximum resistance to rolling) at all angles for a period of about 2·5 seconds (*i.e.*, near the prescribed period), which is presumed to be attributable to some sensitive action of the bulge on the rolling. At the prescribed periods both the naked bulged forms have much less freedom than the unbulged excepting at the low angles. The Revenge form shows less freedom than the Royal Oak,







INDEX TO FIG. 2.

A, B, C—Single rods; D, E—Horizontal frame rocking on horizontal axis E; F—Bell crank rocking on horizontal axis D in frame D, E; G—Frame (rocking on horizontal axis E) rotation of which is controlled by rod C; H—Penrod (recording angle of roll); G_1—Rod secured to frame D, E; H_1—Penrod (recording heave); W—Ballast weight.

but to some extent this is due to the lighter displacement of the former for the same draught. The superiority of the bulged forms is noteworthy when account is taken of their large displacement and metacentric height compared with the unbulged, both of which qualities would in themselves tend to make for more freedom, although the larger GM., as it imposes a shorter period, confers some advantage in this respect. If the metacentric height of the unbulged form were increased to that of the bulged, the periods being also made the same, the freedom of the former would be increased by nearly 50 per cent., the superiority of the bulged form being then very great.

The magnitude of resistance to rolling is, of course, indicated by the smallness of the ordinates to the freedom coefficient curves, and reference to Fig. 6 shows that, although the naked bulged forms are markedly superior to the naked unbulged form, the former are still greatly inferior to the unbulged form with bilge keels, but when the much smaller bilge keels are fitted to the bulged forms, the difference between the three forms is not significant. As a matter of general interest and for comparison with the other forms, curves of extinction (*i.e.*, $\frac{-d\Theta}{dn}$ to base Θ) have been plotted, and are shown in Fig. 7, below; also for forms A and B curves of declining angles are shown in Fig. 10 and Fig. 11, in connection with the "motion ahead" experiments. The extinction can be obtained from the freedom coefficient plotting to a base of angle, thus: If Θ_1 and Θ_2 are the upper and lower limits of the angles of a section, and n the freedom coefficient, then $\frac{-d\Theta}{dn} = \frac{\Theta_1 - \Theta_2}{n}$ very nearly, or if the curve of declining angles is logarithmic (as at the moderate angles it generally tends to be), $\frac{-d\Theta}{dn} = \frac{\Theta \log \frac{\Theta_1}{\Theta_2}}{n}$, *i.e.* $\frac{\Theta \log \sqrt{2}}{n}$. These equations strictly apply at or about the middle point in the section, the precise position of which will not generally make any material difference, but it would be most conformable to the logarithmic principle to take it (*i.e.*, Θ) at the mean proportional angle of the section limits. Both these formulæ give practically identical results for the extinction, but for the first three or so sections where the angle interval is somewhat larger, the extinction was checked and additional spots obtained by differentiation of the curve of declining angles in the usual way. It is seen that the curves of extinction are approximately parabolic only up to about 10 deg. or 12 deg., and that the usual "a" and "b" coefficients accordingly do not apply above these angles, as the curve of extinction is then often flatter than the parabolic curve. The values of the "a" and "b" coefficients for the present models, together with those for a few other forms, are given in Table III.

It is seen from the above coefficients that, with the bilge keels tried, the extinction for the Royal Oak (with bilge keels) is virtually the same as that of the unbulged form, that for the Revenge being a little less; also that both vessels under consideration may (when fitted with the bilge keels as proposed) be expected to have an extinction as great as those which have always held good reputations for sea behaviour. The markedly lower values of "a" assigned to the naked bulged forms, as compared with the unbulged, are in a way fictitious, for although the resistance below about 3 deg. does appear to be slightly less for the former, yet it became necessary to adopt a relatively lower "a" value in order to fit reasonably the extinction curves for the bulged forms at more moderate angles, where their resistance to rolling is very much greater than that of the unbulged form. In other words, "a" and "b" coefficients could only be found to fit the bulged extinction curves at the moderate angles and not at the low or large angles of roll.

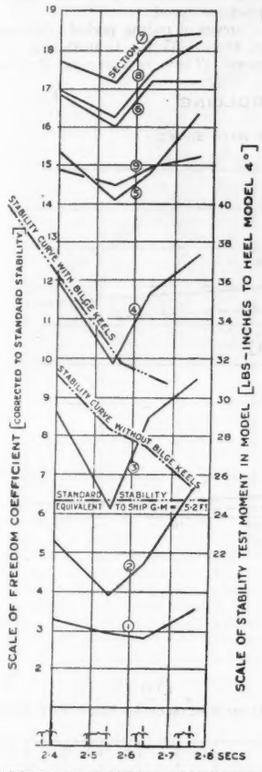
So far as still-water model rolling experiments can

CURVES OF FREEDOM COEFFICIENTS TO BASE PERIOD

MODEL B

Fig. 4.

WITHOUT BILGE KEELS

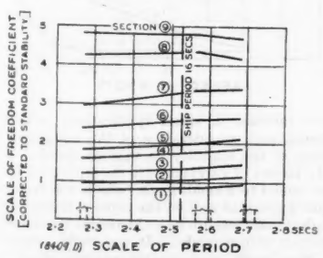

SECTION
STABILITY CURVE WITH BILGE KEELS
STABILITY CURVE WITHOUT BILGE KEELS
STANDARD EQUIVALENT
STABILITY TO SHIP G-M = 5·2 FT
SCALE OF FREEDOM COEFFICIENT [CORRECTED TO STANDARD STABILITY]
SCALE OF STABILITY TEST MOMENT IN MODEL [LBS.–INCHES TO HEEL MODEL 4°]
2·4 2·5 2·6 2·7 2·8 SECS

CURVES OF FREEDOM COEFFICIENTS TO BASE PERIOD

MODEL B

Fig. 5.

WITH BILGE KEELS


SECTION
SHIP PERIOD 16 SECS
SCALE OF FREEDOM COEFFICIENT [CORRECTED TO STANDARD STABILITY]
2·2 2·3 2·4 2·5 2·6 2·7 2·8 SECS
(8409 D) SCALE OF PERIOD

STILL WATER ROLLING RESULTS AT THE PRESCRIBED PERIOD

		CORRESPONDING SHIP PARTICULARS			
		DISPT.	M. DRAUGHT	G.M.	PERIOD OF ROLL
MODEL	A	30600 TONS	33·0 FT.	3·4 FT.	19 SECS.
"	B	33240 "	31·5 "	5·2 "	18 "
"	C	32000 "	"	"	"

Fig. 6.

FREEDOM COEFFICIENTS [CORRECTED TO STANDARD STABILITY]

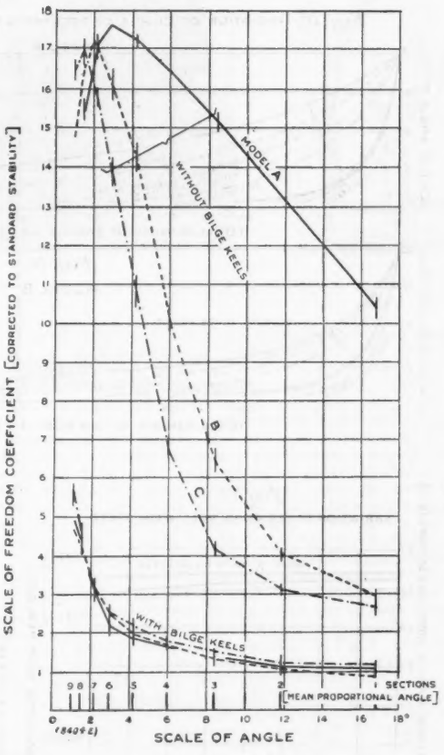

MODEL A
WITHOUT BILGE KEELS
WITH BILGE KEELS
B
C
SCALE OF FREEDOM COEFFICIENT [CORRECTED TO STANDARD STABILITY]
9 8 7 6 5 4 3 2 1 SECTIONS
[MEAN PROPORTIONAL ANGLE]
0 2 4 6 8 10 12 14 16 18°
(8409 E)
SCALE OF ANGLE

Fig. 7.

CURVES OF EXTINCTION

DECREMENTAL EQUATIONS

WITHOUT BILGE KEELS	MODEL A	$-\frac{d\Theta}{dn} = \cdot0184\,\Theta + \cdot0008\Theta^2$
	" B	$= \cdot002\,\Theta + \cdot0066\Theta^2$
	" C	$= \cdot003\,\Theta + \cdot0092\Theta^2$
WITH BILGE KEELS	" A	$= \cdot105\,\Theta + \cdot0175\,\Theta^2$
	" B	$= \cdot070\,\Theta + \cdot022\,\Theta^2$
	" C	$= \cdot070\,\Theta + \cdot0185\,\Theta^2$

NOTE: THESE DECREMENTAL EQUATIONS APPLY FAIRLY WELL TO THE RESPECTIVE CURVES UP TO ANGLES INDICATED BY A STOP THUS ✗ ON THE CURVES

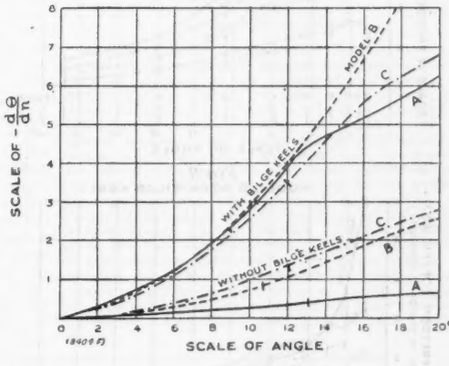


TABLE III.

	Displacement (tons).	G.M. (ft.).	T (sec.).	"a" Coefficient.	"b" Coefficient.	Remarks on "a" and "b" Coefficients.
Experiments on Ships.						
Revenge (1894) (ex B.K.'s)	14,300	3·78	15·2	0·0123	0·0025	Applies fairly well up to 10 deg.
Revenge (with B.K.'s) ..	14,620	3·86	15·5	0·065	0·017	Applies fairly well up to 5 deg.
King George V (with B.K.'s)	25,350	5·53	14·7	0·113	0·0097	Rolled up to 5½ deg. only.
Experiments on Models.						
Royal Sovereign A (unbulged)	30,600	3·4	19·0	0·0184	0·0008	Too large below 13 deg.
Royal Sovereign A2 (with B.K.'s)	—	—	—	0·105	0·0175	Too large above 12 deg.
Royal Oak B (bulged) ..	33,240	5·2	16·0	0·002	0·0066	Too low above 10 deg.
Royal Oak B2 (with B.K.'s)	—	—	—	0·070	0·022	Applies fairly well throughout.
Revenge C (bulged)	32,000	—	—	0·003	0·0092	Applies fairly well up to 12 deg.
Revenge C2 (with B.K.'s) ..	—	—	—	0·070	0·0185	Too large above 12 deg.
Hood (naked)	45,200	5·0	17·5	0·008	0·0036	Too small above 9 deg.
Hood (with B.K.'s)	—	—	—	0·045	0·01	Too small above 7 deg.

explain the differences in the behaviour at sea of the unbulged form (fitted with bilge keels) and the bulged (*ex* bilge keels), it is considered that the curves on Figs. 4 to 7 and a comparison of the data for these forms give an indication of the main reasons for the inferiority of the latter.

The effect of bilge keels on period was tried on Model B, the ballast being identical in the model with and without bilge keels, their removal being effected without shifting the ballast in any way. The period with the keels fitted was 2·56 seconds and without them 2·49 seconds, the lengthening of the period by the keels corresponding in the ship to about 0·45 second. Some years back Mr. R. E. Froude found as a result of model experiments on the Hood that the lengthening of her rolling period by the relatively smaller bilge keels was about 0·35 second.

Experiments to Determine the Effect of Motion Ahead on Rolling.

It was desired to have some idea of the manner in which the foregoing extinction experiments might be affected by ahead motion. It is, of course, a very general experience that ships roll less when under steam than at rest, and some experimental results confirming this were given (for the old Revenge) by the late Sir William White in his paper on "Notes on Further Experience with First-Class Battleships."* Similar confirmation, though of a more striking character, was also found about 20 years ago by Mr. R. E. Froude in some rolling experiments made on the torpedo-boat destroyer Star. The following is an extract from Mr. Froude's report on these experiments: "For the ship not under way . . . the extinction with bilge keels is twice to three and a-half times that without them. But . . . the effect of headway is greater still, the extinction added (without bilge keels) by the speed of 17 knots being quite twice as great as that added by bilge keels with ship not under way." In the tank it is impossible to carry out any very useful experiments to determine the effect on rolling of ahead motion amongst waves, since the waves necessarily move in the same or opposite direction as the model, and it was accordingly decided to restrict the motion ahead experiments to still water. After trying a more elaborate method of constraining the model, it was found satisfactory to do so merely by bow and stern lines (secured to the model at the rolling axis—practically as in the previous experiments); the bow line was led to a fixed position on the truck and the stern line was led over a sheave and carried a 5- or 10-lb. weight.* The same recording apparatus was used as before with its position on the truck suitably modified (on account of the different relative position of the model). The rolling of the model is worked up by hand or the model held over (to about 20 deg.), during the period of acceleration on the run, so that the whole of the period of uniform run is available for the extinction of rolling; at a speed compounding to 20 knots the time available (about ¾ minute) is so short that the model is still rolling to an appreciable angle at the end of the run. In such cases experiments with a smaller initial angle were made subsequently. The experiments were confined to Models A and B (the unbulged and Royal Oak bulged forms respectively), with and without bilge keels; the speeds corresponded to 10, 15 and 20 knots. The models were tried at one period only, the ballast being disposed to give the model the prescribed stability and period as nearly as possible.

The same system of analysis was adopted as before and the results are shown for Model B in the form of freedom coefficients to a base of angle in Figs. 8 and 9. In the naked models the effect of the headway to increase extinction is considerable, and much more so at the small than at large angles. At 20 knots with the unbulged form the extinction is 2½ to 4 or 5 times as great, and in the bulged form 1½ to 3 or 4 times as compared with the model stationary. The effect of headway on the rolling of the model when fitted with bilge keels is much less impressive and almost negligible at the large angles, where the extinction without headway is so large; it becomes, however, very apparent at the smaller angles, and the extinction is almost doubled in amount at 2 deg. or so at a speed of 20 knots compared with at rest. A slight increase of freedom at 10 knots was found for both the bulged and unbulged forms, which seems suggestive of an anomaly, but it is considered it may be dismissed and regarded as an experimental error rather than a genuine feature, the freedom being so small. In Figs. 10 and 11 the results of the underway experiments are shown in the form of curves of declining angles for both models, and a cursory glance at the curves will show that the effect of motion ahead (particularly at the high speeds) does to a fair extent serve to bridge the large gap between the curves for naked models and model with bilge keels when the ship is not under way. The effect of headway is seen to be relatively much more marked in the unbulged form A than in the bulged form B, but the latter is still (as before) more extinctive than the former, although at small angles it appears to be at a slight disadvantage. The extinction of both forms, however, is then so large compared with the at rest experiments that this small difference may be disregarded. With bilge keels there is very little to choose between the two forms, at all angles, speed for speed.

Fig. 12 shows curves of rolling period (the mean of sections 6–9, *i.e.*, from 3·53 deg. to 0·88 deg.) plotted to a base of speed. There is a general decrease in period with increase in speed (particularly with the bulged forms), and consideration of this suggested an investigation of the stability at various speeds. The most ready means of carrying this out appeared to be to heel the model to a small angle (which was recorded by the same apparatus and on the same cylinder as the rolling angles) and measure how the record was affected by the motion of the model. It was early apparent, however, that some considerable magnification was necessary to obtain any accurate results, also that yawing must be entirely eliminated. The latter was effected by fitting the model with the usual fore and aft guiders, but with the ball and socket joint arranged approximately at the height of the C.G. To magnify the record the horizontal arm of the bell crank of the automatic rolling apparatus was fitted with an additional pin, so that the arms, instead of being equal, were now in ratio 4 : 1; the scale of record was thus increased from 1 in. 10 deg. to 1 in. 2½ deg.* Again, to measure the effect of any change in stability on the inclination

VARIATION OF FREEDOM COEFFICIENT WITH SPEED

Fig. 8. MODEL B WITHOUT BILGE KEELS

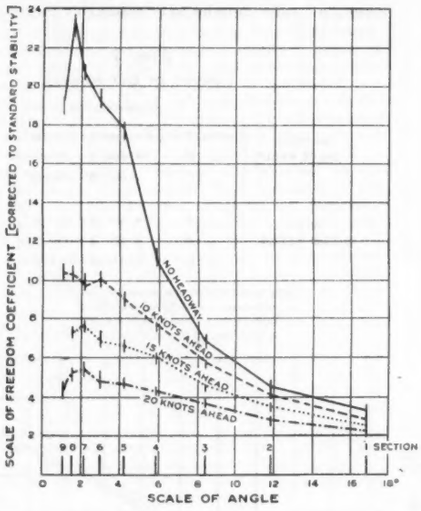
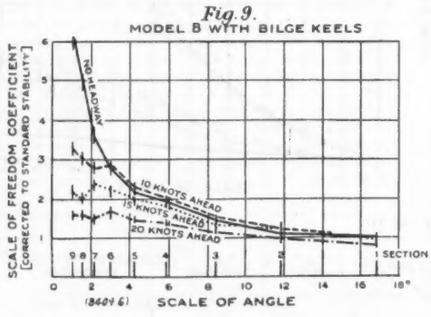


Fig. 9.

MODEL B WITH BILGE KEELS



(8404 6)

EFFECT OF MOTION AHEAD ON ROLLING

Fig. 10. VARIATION OF CURVE OF DECLINING ANGLES WITH SPEED

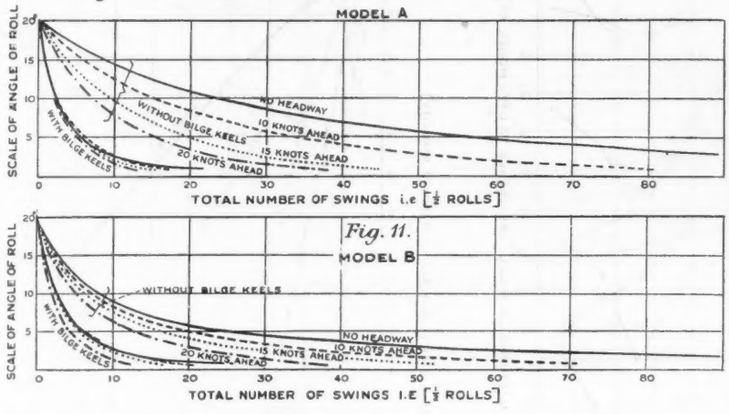


Fig. 11.

Fig. 12.

VARIATION OF PERIOD OF ROLL WITH SPEED

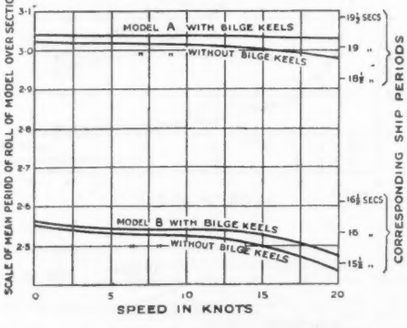
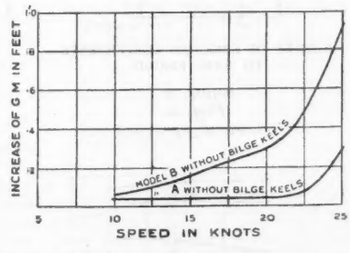

SCALE OF MEAN PERIOD OF ROLL OF MODEL OVER SECTIONS [6–9]
MODEL A WITH BILGE KEELS
" " WITHOUT BILGE KEELS
MODEL B WITH BILGE KEELS
" " WITHOUT BILGE KEELS
CORRESPONDING SHIP PERIODS
SPEED IN KNOTS

Fig. 13.

VARIATION OF METACENTRIC HEIGHT WITH SPEED



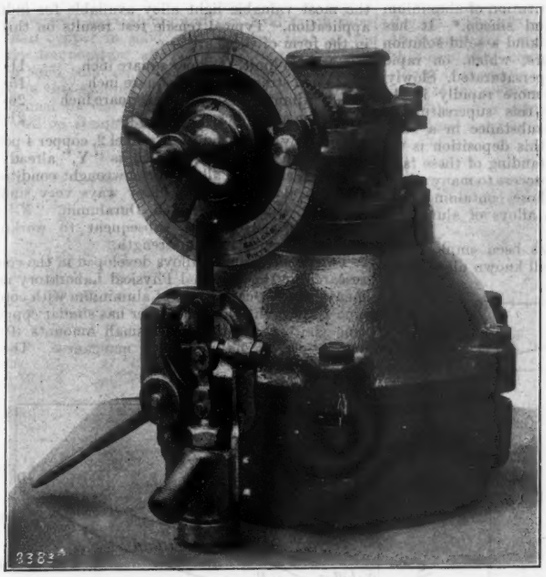
* Trans. I.N.A., vol. xxxvi.

* The heavier weight was necessary at the top speed to prevent yawing.

* Owing to the consequent lack of symmetry the scale was not uniformly 1 in. 2½ deg., but was carefully calibrated to measure any inclination.

METER ATTACHMENT FOR FIXED QUANTITIES OF LIQUIDS; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. BECK AND CO., LIMITED, ENGINEERS, LONDON.



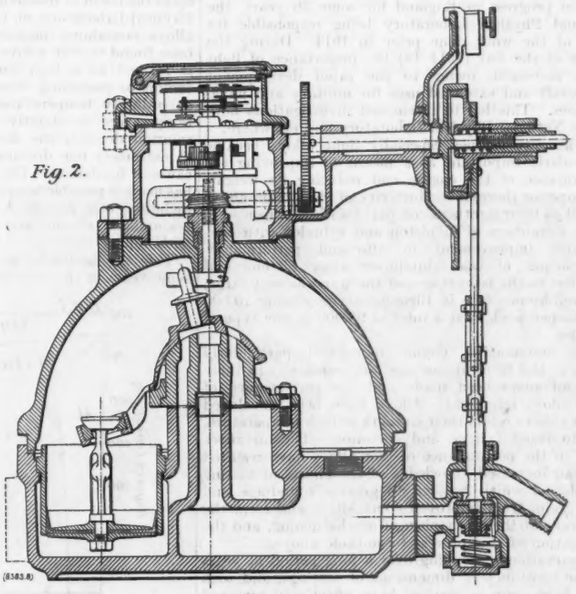


Fig. 2.

FIG. 1.

the GM. was reduced to as low a figure as appeared convenient, actually corresponding to about 1 ft. The models were ballasted to take up an inclination at rest of 3 deg. and the angle was recorded on the run at various speeds (10 to 25 knots). The reduction of inclination was sufficient to be read off with accuracy, and the rise of the metacentre and therefore increase of GM. was readily calculated. The results are shown plotted in Fig. 13. It is seen that there is a pronounced increase in GM. with speed which is more marked in the bulge form, and this accounts satisfactorily for the decline in rolling period found with increase in speed, the period being roundly proportional inversely to $\sqrt{GM}$ at all speeds. The question of effect of ahead motion on stability was investigated rather fully by Mr. G. S. Baker and Miss Keary in their paper, "The Effect of Longitudinal Motion of a Ship on its Transverse Stability,"* read in 1918. For most of the forms then dealt with it was found that the stability diminished when under way, but for one form (a torpedo-boat destroyer) it was increased at low and moderate speeds. Of the forms for which results are now given it appears that the effect of ahead motion on stability most nearly resemble the T.B.D., their speeds, as far as they can be correctly described as corresponding, being within the range in which the stability of the destroyer is increasing. It is not surprising that the bulged type of midship section is specially favourable to such increase of stability with speed.

(To be continued.)

METER ATTACHMENT FOR DELIVERING FIXED QUANTITIES OF LIQUIDS.

IN many industrial processes it is necessary to mix liquids in definite proportions or to supply a fixed quantity of fluid to some other ingredient. The well-known "Imperial" positive water meter, which is made by Messrs. Beck and Co., Limited, 130, Great Suffolk-street, Southwark, S.E.1, has recently been fitted with an attachment for this purpose, and a meter so arranged forms part of the firm's exhibit in the Palace of Engineering at the British Empire Exhibition. The fitting which we illustrate in Figs. 1 and 2 above enables the meter automatically to supply a given quantity of liquid and then to cut off the flow. It has been satisfactorily employed to control the delivery of gas oil to carburetted water-gas plants, but is obviously applicable to other processes involving the supply of a measured quantity of liquid at frequent intervals.

The appearance of a meter with the attachment in place is shown in Fig. 1, while the design and construction of both can be followed by examining the sectional drawing reproduced in Fig. 2. Before dealing with the attachment we may first briefly describe the construction of the meter itself. This contains three cylinders and pistons, only one of which is shown in Fig. 2, arranged at equal intervals around the vertical axis, and the piston rods are each connected to an arm extending radially from a cup-shaped gun-metal-valve working on a spherical seating. This seating, which is of vulcanite when the meter is used for measuring water, contains three ports communicating with passages leading to the spaces below the pistons, and a fourth port in the centre leading to the outlet. Water from the inlet connection, not shown in the illustration, passes through a strainer into the upper part of the casing exerting an equal pressure on all the pistons and forcing down one of them which has the space below it connected to the outlet through a passage in the valve, as shown in Fig. 2. At the same time the other pistons are drawn up and water flows into the space below them through the ports in the valve seating above referred to, which are uncovered by slots in the valve. These pistons, in their turn, are forced downwards, the contents of the cylinders being discharged to the outlet, and the action continuing indefinitely as long as water can escape from the outlet. The rotary motion imparted to the valve by the reciprocating motion of the pistons is communicated by a pin at the top to a spindle connected to the integrating mechanism which shows the total quantity delivered on dials of the usual type.

For the particular application to which we are now referring, an additional horizontal spindle, carried on a bracket and connected by spur gearing to the integrating mechanism, is provided, as shown in Fig. 2. Fixed to the bracket is a dial provided with an adjustable stop and engraved, as shown in Fig. 1, so that the stop can be set for any required delivery; in this case up to 10 gallons. The end of the spindle extends through the centre of the dial and terminates in a small spring-controlled cone clutch, the male member of which carries a radial arm. The latter is arranged so that the rotation of the spindle will bring the arm into contact with a vertical lever, clearly shown in Fig. 1, and this lever is connected by a toggle link to the stem of a valve controlling the outlet. With the valve closed, the adjustable stop on the dial is set to the required delivery and, by pulling out the male member of the clutch against the action of the spring, the radial arm can be turned in a clockwise direction until it comes into contact with the stop. The clutch handle is then released so that the two parts come into engagement, and the valve is opened by means of the hand lever shown on the left of Fig. 1. The flow through the meter then causes the radial arm to rotate in an anti-clockwise direction until it comes into contact with the valve lever and closes the valve after the required quantity has been delivered. The attachment can be arranged to deliver any quantity of liquid and the accuracy of measurement is within 1 per cent.

* Trans. I.N.A., vol. lx, page 74.

BRITISH EMPIRE EXHIBITION PUBLICATIONS.—An official guide, providing general information on the exhibits in each of the buildings comprising the British Empire Exhibition has been prepared, and is now on sale at a price of 1s. In it a folder is provided giving a map, showing the positions of the various sections, while information is afforded on the routes by which the Exhibition can be reached. An official catalogue has also been published at a price of 1s., which gives information on the exhibits in every section; the Palace of Engineering, the Palace of Industry, and the buildings of the various Dominions and Crown Colonies. As this catalogue gives, not only stand numbers, but also the numbers of the avenues and bays in which the stands are situated, its use facilitates greatly the location of any particular exhibit in the buildings. Both the guide and the catalogue are published by Fleetway Press, Limited, of 3 to 9, Dane-street, High Holborn, London, W.C.1.

SOLID DIFFUSION INTO ALLOYS.—On behalf of himself and of Mr. W. H. Dearden, M.Sc., Professor F. C. Thompson, of Manchester, described before the Faraday Society on April 14, some experiments made for the purpose of choosing between the two structures that have been proposed for solid solutions. Dr. Thompson had himself stated in 1917 that when metal B was added to metal A, the lattice of the solution was that of the solvent A, that is to say, atoms of B replaced atoms of A, the lattice being merely deformed by the attempt of the two atoms to become of similar volume. The other view assumed that the atoms of the metal B found places in the spaces between the atoms of A in the original lattice. X-ray work left the question undecided. The former view seemed to explain why certain alloys were harder than their constituents. On the other hand the rate of cementation of alloy steels indicated that it took carbon less time to penetrate into a plain carbon steel than into steel alloyed with nickel. In his experiments Dr. Thompson took copper, silver and gold, three metals of almost the same atomic volumes. A small pallet of each material was hammered into a smaller hole in a seperate block of remelted electrolytic copper; the specimens were then annealed for 70 hours at 650 deg. C. in vacuo and prepared for examination. Bands of the copper diffusing into the other metal became visible and they had different widths in the different cases; the width was 0·075 mm. in an alloy of gold and silver (50·50); 0·15 mm. in silver and 0·23 mm. in gold. Thus diffusion had taken place more readily into the pure metals than into the alloy, and that Dr. Thompson suggested, would more easily be understood if the metal B filled up spaces in the lattice of metal A than if it were to replace the atoms of A. This work has caused him to change his views on the subject.

LIGHT ALLOYS OF ALUMINIUM.*

By W. ROSENHAIN, D.Sc., F.R.S., and S. L. ARCHBUTT, F.I.C. (from the National Physical Laboratory, Teddington).

RESEARCH on the light alloys of aluminium has been in progress in England for some 20 years, the National Physical Laboratory being responsible for most of the work done prior to 1914. During the course of the war (1914–18) the importance of light alloys increased, owing to the rapid development of aircraft and extended uses for military and naval purposes. This led to intensified investigations both at the National Physical Laboratory and elsewhere.

In aircraft engines especially light alloys became particularly important as a means of improving the performance of the engine and reducing its weight. The superior thermal conductivity of aluminium alloys as well as their lightness compared with cast iron were taken advantage of in piston and cylinder with considerable improvement in all-round performance. The output of cast aluminium alloy pistons and cylinders in the later stages of the war was very large, one well-known firm in Birmingham producing 10,000 pistons per week, and a total of 95,000 of one type of cylinder.

The aeronautical engine demanded particularly alloys in the form of castings, and especially in these have advances been made and the performance of light alloys improved. Alloys have been developed better able to retain their strength at high temperature, and to resist fatigue and corrosion. The advances made in the performance of cast alloys have resulted from an increased knowledge of the effects of casting conditions, which has led to greater soundness and finer grain, from improved composition and from the discovery of the mechanism of age-hardening, and the application of this process to suitable alloys.

Observations extending over a long period of years on the constancy of dimensions of castings, and with their behaviour in service, have effectively removed doubts as to the stability of aluminium-rich alloys in general, and the permanent stability of a large range of the light aluminium alloys of to-day is now well established.

The ratio of strength to density is a useful measure of the comparative value of materials for constructional purposes. For a 30-ton mild steel the ratio of ultimate tensile strength (tons per square inch) to weight of 1 cub. in. (lb.), or "specific tenacity," as it has been termed,† is approximately 105. We have to-day light aluminium alloys which in the wrought condition have a specific tenacity as high as 360, and in the cast condition 260, equivalent to steels having a tensile strength of the order of 100 and 80 tons per square inch respectively. This property of specific tenacity may be expressed in terms of the vertical length which a material will just support when suspended from one end. In the case of a 30-ton steel this length is about 3·75 miles; for the light alloy first mentioned the figure is 12·5 miles in the wrought and 9 miles in the cast state.

A property of the greatest importance in the case of parts, such as connecting rods, shafts, &c., subjected to repeated reversals of stress, is resistance to fatigue. The safe range of stress, at all events up to 6,000,000 reversal of stress, for one of the best light alloys in the wrought condition is ± 10 tons per square inch, but no appreciable further improvement has yet been effected on this value. In the case of cast alloys, however, the safe range of stress has recently been increased from approximately ± 3 tons per square inch to ± 7 tons, a remarkable advance.

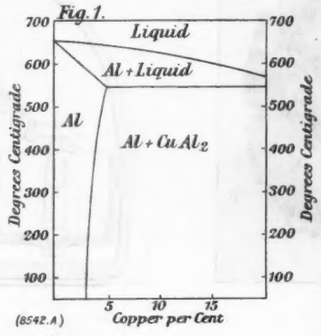
The improvement in performance of light aluminium alloys as the result of recent research is exemplified in Table I.

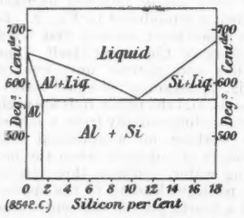
TABLE I.

Property.	Values increased from—	
	Cast.	Wrought.
Elastic limit (tons per square inch)	3 to 8–9	12 to 22
Tensile strength—normal temperature (tons per square inch)	12 to 20	27 to 39
Tensile strength—250 deg. C. ..	7 to 11	—
Specific tenacity	130 to 260	270 to 360
Fatigue range (tons per square inch)	±3 to ±7	±10 to ±10

One of the most valuable discoveries in connection with the improvement of the mechanical properties of light aluminium alloys has been that of the mechanism of age-hardening. The property of age-hardening, discovered by Wilm as an effect of the introduction of magnesium, causes the alloys, after quenching from a suitable temperature, to undergo a gradual hardening in the course of several days. The mechanism of this curious property was never understood or explained by its discoverer, but has been fully cleared up as the result of researches carried out at the National Physical Laboratory, on the constitution of aluminium alloys containing magnesium and silicon.* It has been found that in alloys of this kind a solid solution is formed at a high temperature, which, on rapid cooling or quenching, becomes supersaturated. Slowly, at ordinary temperatures, and more rapidly if the temperature is slightly raised, this supersaturated solution deposits the dissolved substance in a state of extremely fine division, and this deposition is the cause of hardening. The understanding of these facts has made it possible to apply the process to many alloys, including cast materials, both those containing magnesium and silicon, and certain alloys of aluminium with copper alone.

This age-hardening process has been employed for some years in the case of the well-known alloy Duralumin in the wrought condition; recent research at the National Physical Laboratory, however, has shown that certain cast alloys can be strengthened to a marked extent by this means. Thus the tensile strength of an alloy containing copper 4, nickel 2, magnesium 1·5 per cent. (aluminium remainder) in the cast condition can be increased from 12 to 20 tons per square inch.





By an annealing and quenching treatment the tensile strength of a binary copper-aluminium alloy containing 4·5 per cent. of copper in the cast condition can be raised from 9 to 17 tons per square inch, accompanied by a large increase in ductility. The application of the age-hardening process to certain wrought aluminium alloys has led to the attainment of tensile strength of 39–40 tons per square inch in an alloy of density 3·1 grammes per cubic centimetre.

The aluminium alloys at present in general industrial use are confined to comparatively few types of composition: these include two binary alloys of aluminium with copper, containing from 6 per cent. to 8 per cent. and 12 per cent. of copper respectively; a ternary alloy with copper and zinc containing about 3 per cent. copper and 12 per cent. to 14 per cent. zinc, which are used very extensively. Binary alloys with silicon have lately come into prominence for castings, owing to the discovery of a method of treating the molten alloys which causes them to solidify with a fine-grained structure. The resulting castings are very sound and of good appearance and combine reasonable strength with good ductility. Two compositions are principally used with silicon contents around 9 per cent. and 13 per cent. respectively. An alloy more complicated in type than those above mentioned, and having the normal composition magnesium 1·5, nickel 2, copper 4 per cent. (aluminium remainder), first developed as a casting alloy at the National Physical Laboratory, is now finding extended use.

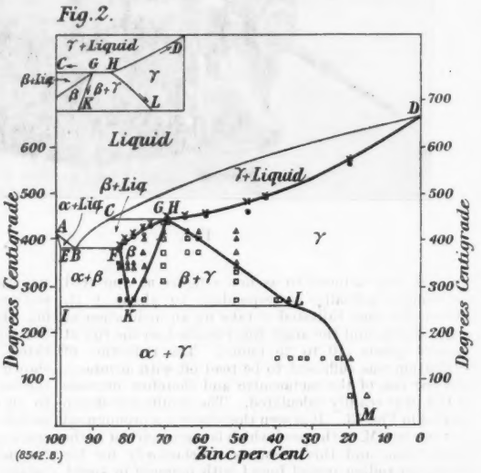
In addition to these types of alloys, for some of which aircraft specifications have been in use for some time, efforts to develop other types have not been wanting. Extensive search has, however, led to nothing better, although there are numerous proprietary alloys for which large but not always reliable claims are made.

Up to the present no outstanding improvement in cast alloys has been effected by many other compositions tried. In regard to wrought material the proprietary alloy Duralumin still largely holds the field, partly because it was developed early and for some time was the most valuable light alloy available for industrial application. Typical tensile test results on this alloy in the form of sheet are:—

Elastic limit, tons per square inch	11·4
Yield stress, tons per square inch	15·7
Maximum stress, tons per square inch....	26·7
Elongation, per cent. on 2 in.	21·0

The alloy magnesium 1·5, nickel 2, copper 4 per cent. (aluminium remainder), known as "Y," already mentioned as a casting alloy, in the wrought condition has mechanical properties in many ways very similar to those of Duralumin. Like Duralumin, "Y" alloy requires heat-treatment subsequent to working, in order to develop its full strength.

Two other wrought alloys developed in the course of research at the National Physical Laboratory may be mentioned. One consists of aluminium with copper 3, zinc 20 per cent., and the other has similar copper and zinc content together with small amounts (0·5 per cent.) of magnesium and manganese. The first mentioned, known as "A" alloy, has mechanical properties similar to those of Duralumin, but does not need heat-treatment for their development. The last mentioned, known as "E" alloy, requires heat-treatment, but a tensile strength of 40 tons per square inch has been obtained from heat-treated rolled rod of this material. With the exception of the binary alloys of aluminium with silicon, the above-mentioned alloys may be considered to be developed from one or other of the binary systems of aluminium with copper or zinc. The microstructure and properties of these two systems are therefore of interest.



Copper-Aluminium Alloys.—The addition of copper to aluminium rapidly hardens it and reduces ductility. Little advantage as regards tenacity of the cast alloys at ordinary temperature is gained by adding more than 4 per cent., and the same remark holds good in the case of rolled material. The greater hardness, strength at high temperature, and improved casting properties of alloys with higher copper content are, however, valuable.

The tensile properties* of some of these alloys in the form of 1 in. diameter chill-cast bars are given in Table II.

TABLE II.—*Copper-Aluminium Alloys (1. in diameter Chill-Cast Bars). Tensile Tests.*

Copper per cent.	Maximum Stress. Tons per Sq. In.	Elongation per cent. on 2 in.	Hardness (Brinell).	Density. Grammes per c.c.
0	5·2	37	—	2·70
2	8·2	17	—	2·75
4	9·6	10	—	2·81
6	9·9	5	—	2·85
8	10·6	3	60	2·90
12	—	—	82	—

The constitution of these alloys up to 20 per cent. copper is represented in Fig. 1.† The diagram shows

* Paper read before Section D of the Empire Mining and Metallurgical Congress, June 4, 1924.

† "Tenth Report to the Alloys Research Committee of the Institution of Mechanical Engineers," page 359.

* "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers," 1921.

* Carpenter and Edwards, "Eighth Report to the Alloys Research Committee of the Institution of Mechanical Engineers."

† Gayler, *J. Inst. Metals*, 1922, vol. xxviii, page 214.

that whereas at 500 deg. C. aluminium will hold about 4·5 per cent. of copper in solid solution, at ordinary temperature this solubility has decreased to about 3 per cent. These alloys can accordingly be improved by heat treatment.

Zinc-Aluminium Alloys.—The constitution of this system has recently been revised at the National Physical Laboratory,* and is represented in Fig. 2. It will be seen that aluminium can hold much more zinc than copper in solid solution, and that at the ordinary temperature about 18 per cent. of zinc is held in solid solution. Moreover, no compounds are formed in this system. The greater solubility of zinc is explained by the fact that the hardening effect of this metal on aluminium is less than that of copper.† in the cast condition a network of a second constituent ($CuAl_2$), zinc-aluminium alloys up to high percentages of zinc show dendritic cored structures and no network.

Silicon-Aluminium Alloys.—The constitution of this system up to 20 per cent. silicon is shown in Fig. 3.* Silicon is seen to be sparingly soluble in solid aluminium up to a maximum of about 1·5 per cent. at about 580 deg. C. The eutectic alloy contains approximately 10·5 per cent. silicon. The normal structure of a chill-cast alloy containing approximately 12 per cent. silicon is shown in Fig. 4 at 150 diameters. By treatment of the melt with a very small quantity of sodium or with a flux containing sodium fluoride a modified structure very much finer in grain is obtained, as illustrated in Fig. 5, also at 150 diameters. Tensile tests† on some silicon-aluminium alloys in the "modified" condition are given in Table IV.

alloys have been developed. In regard to constitution, the solidified alloys up to 3 per cent. of copper and considerably higher percentages of zinc consist, when in equilibrium, of a single solid solution. The tensile properties* of some typical alloys of this ternary system are given in Table V. It will be observed that these alloys give better tenacity and ductility for equal density than either the binary copper or the binary zinc-aluminium alloys.

Magnesium-Nickel-Copper ("Y") Alloy.—This alloy has been arrived at in the course of a search for a light alloy able to retain its strength at comparatively higher temperatures. The constitution of alloys of this type is not yet completely worked out. In the absence of magnesium an alloy containing copper 4, nickel 2 per cent., aluminium remainder, consists when in equilibrium of three constituents—a matrix of crystals of aluminium containing small quantities of copper and nickel in solid solution, a network consisting of the compound $NiAl_3$, and a ternary constituent containing aluminium, nickel and copper. The copper-aluminium eutectic point at 530 deg. C. is absent, and

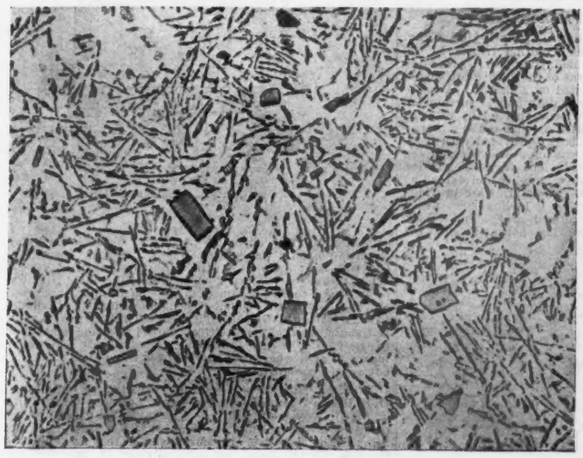


FIG. 4. SILICON-ALUMINIUM ALLOY. UNMODIFIED. × 150.

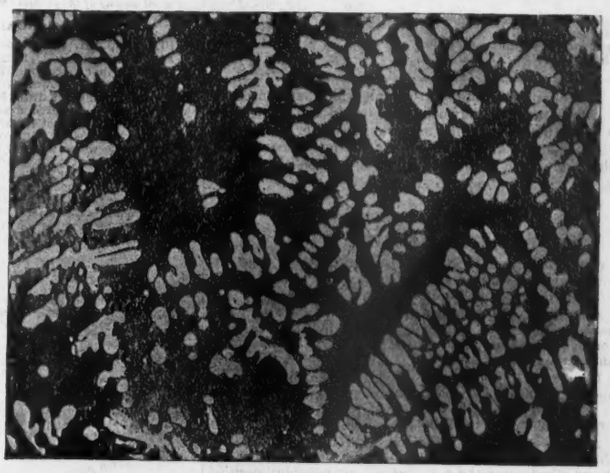


FIG. 5. SILICON-ALUMINIUM ALLOY. MODIFIED. × 150.

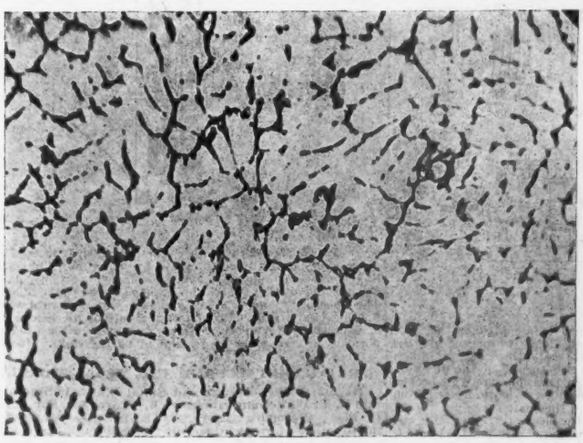


FIG. 6. "Y" ALLOY. 1-IN. DIAMETER CHILL.

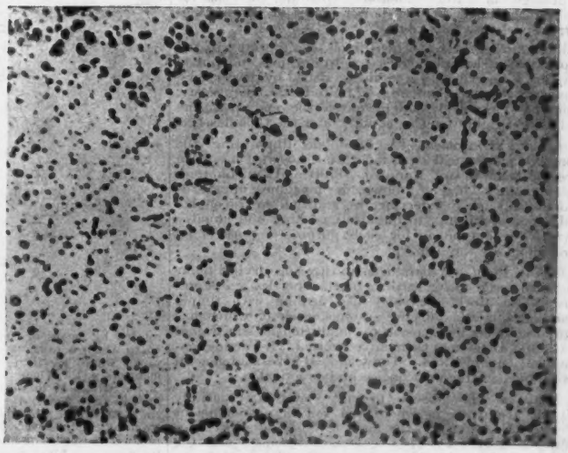


FIG. 7. "Y" ALLOY. 1-IN. DIAMETER CHILL. HEAT-TREATED.

This is seen from the tensile test results given in Table III, on 1 in. diameter chill-cast bars.

TABLE III.—*Zinc-Aluminium Alloys. Tensile Tests (1 in. diameter Chill-Cast Bars).*

Zinc per cent.	Maximum Stress Tons per Sq. In.	Elongation per cent. on 2 In.	Density Grms. per c.c.
0	5·2	37	2·70
5	6·6	29	2·76
9	7·8	11	2·84
13	10·7	10	2·93
16	11·4	6	2·99
19	13·7	7	3·05
23	13·5	3	3·15

Microstructure.—Whereas binary copper-aluminium alloys containing more than 2 per cent. of copper show

TABLE IV.—*Silicon-Aluminium Alloys. Tensile Tests.*

Silicon per cent.	Maximum Stress. Tons per Sq. In.	Elongation per cent. on 2 In.	Density. Grms. per c.c.
8	10·0	10·0	2·67
10	12·5	9·0	2·66
13	14·7	7·5	2·65

The alloys are lighter than the binary copper or zinc-aluminium alloys, and possess good tenacity and excellent ductility.

Copper-Zinc-Aluminium Alloys.—By combining the hardening actions of copper and zinc some interesting

TABLE V.—*Copper-Zinc-Aluminium Alloys. Tensile Tests (1 In. Diam. Chill Cast Bars).*

Copper per cent.	Zinc per cent.	Maximum Stress. Tons per Sq. In.	Elongation per cent. on 2 In.	Density. Grammes per c.c.
1	10	11	15	2·96
3	10	13	11	2·93
1	15	13	10	2·96
2	15	15	16	2·99
3	15	14	7	3·03

* Hanson and Gayler, *J. Inst. Metals*, 1922, vol. xxvii, page 267.

† Rosenhain, Proc. Roy. Soc., 1921 [A], vol. xcix, page 196.

* Hanson and Gayler, *J. Inst. Metals*, 1921, vol. xxvi, page 323.

† Aitchison, *Inst. Automobile Eng.*, 1924 (Advance copy).

* "Eleventh Report to the Alloys Research Committee, Institution of Mechanical Engineers," 1921.

the solidus is raised to a temperature in the neighbourhood of 580 deg. C. "Y" alloy does not appear to offer any special difficulties in casting in either sand or chill moulds, and is valuable in regard to strength at high temperatures, elasticity, improvements of properties by heat-treatment and resistance to corrosion, as compared with most other available light alloys. Some typical properties are enumerated below:

Properties of "Y" Alloy.

	Cast.	Cast and Heat-treated.
Density (grammes per c.c.) ..	2·79	2·79
Elastic limit (tons per square inch)	5·6	7·0
Maximum stress (tons per square inch)	13·0	20·0
Elongation (per cent. on 2 in.) ..	2·0	5·0
Hardness (Brinell)	76·0	105·0
Fatigue range (tons per square inch)	—	±7·0

The change in microstructure which accompanies heat-treatment is shown in Fig. 6 and Fig. 7 relating to 1 in. diameter chill-cast bars. Higher values for ultimate stress and elongation of the heat-treated cast alloy have been obtained than those given above.

(To be continued.)

CATALOGUES.

Cast-iron Pipes.—A list of cast iron pipes in stock for immediate delivery is issued monthly by the Stanton Ironworks Company, Limited, near Nottingham.

Aeroplanes.—A catalogue giving particulars of aeroplanes suitable for military, commercial, and instructional purposes is to hand from the Bristol Aeroplane Company, Limited, Bristol.

Wireless Apparatus, &c.—Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E.18, have sent us a revised catalogue of wireless receiving sets, accessories, primary cells and batteries.

Trucks.—Mr. H. C. Slingsby, 85, Kingsway, London, W.C., has forwarded us a catalogue of jack-lift hand trucks, illustrating the convenience and economy derived from their use in various lifting and transporting operations.

Electric Condensers.—The Westinghouse Electric International Company, 2, Norfolk-street, Strand, have issued a catalogue of static condensers explaining their use for the improvement of the power factor of alternating-current systems.

Mechanical Stokers.—The Illinois chain-grate stoking apparatus, as adapted for use with natural and forced draught, is described in a catalogue issued by the Vickers-Spearing Boiler Company, Limited, 20, Kingsway, London, W.C., who have acquired the manufacturing and selling rights for this country and the Colonies.

Hospital Equipment.—A catalogue illustrating the complete mechanical equipment of a hospital has been received from Messrs. Manlove, Alliott and Co., Limited, Nottingham. There are shown, the machines, apparatus and utensils for disinfecting, in addition to the engine and boiler, sterilising, incinerating, cooking and laundry work. The equipment for each purpose is constructed throughout by the firm.

Drying Plant.—A catalogue illustrating drying plant specially designed for leather, barrels, bottles, grass and corn in the stack, &c., and also dealing with tunnel chamber, and other drying systems, each of which has many useful applications, is to hand from Messrs. James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C.4. The technical notes and general descriptive matter are concise and practical.

Drainage System.—A drainage system especially suitable for districts where the fall is not sufficient to carry the sewage to the main drain is described in a catalogue issued by Messrs. Daniel Adamson and Co. Limited, Dukinfield, Manchester. The sewage falls to an underground chamber below the level of the main drain and is then raised by compressed air into the main drain. The whole system and apparatus is illustrated.

Road-making Machines.—A catalogue illustrating about fifty machines for preparing stone for road-making, railway track ballasting, and similar work is to hand from Messrs. H. R. Marsden, Limited, Leeds. The machines include traction engines, road rollers, rock breakers, screening, elevating and conveying plant, and concrete and tar-macadam preparing plant. Portable and fixed types are made in most cases and complete plants for quarries are also supplied.

Oil and Petrol Engines.—A new edition of their catalogue of oil and petrol engines is to hand from the Parsons Motor Company, Limited, Southampton. The catalogue deals with the general construction of marine engines with reversing gears and speed-reducing gears, a speed-reducing gear and clutch for fixed engines, and also includes specifications and prices for marine engines from 14 h.p. to 90 h.p. The last-mentioned size has six cylinders and develops 95 h.p. on petrol and 76 h.p. on oil. A second series of engines from 7 h.p. to 90 h.p., of generally similar construction but suitable for stationary work, is also fully described, and prices are stated for each size. All the usual dimensions and technical particulars are given, and every set, component and auxiliary is allotted a code word to facilitate ordering by telegraph.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

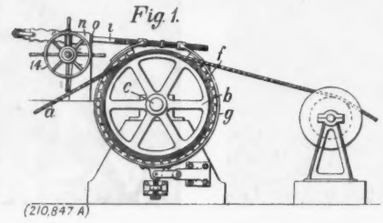
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

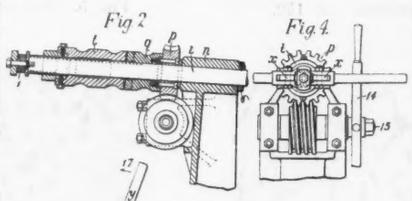
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

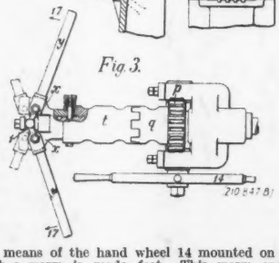
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

210,847. J. M. Rutherford, Duns. Cable-laying Gear. (4 *Figs.*) November 4, 1922.—The invention relates to the brakes used in connection with cable-laying gear. According to the construction shown, several turns of the cable *a* are wound around the paying out drum *b* mounted on a shaft *c*. A brake sheave *f* is also mounted upon the shaft *c* and is surrounded by a band brake *g* that is caused to press thereon by rotating a shaft *l*. The shaft *l* is provided with a collar *o* and a worm-wheel *p*. The worm wheel *p* has a boss *q* provided with teeth adapted to engage corresponding parts of a sleeve *t* adapted to slide on a feather or key on the shaft *l*. The sleeve *t* is provided with two arms *x* diametrically opposite each other and extending in a direction parallel to the shaft *l*. These arms are provided at their outer extremities with levers *y* having ends which extend into an annular channel 1 formed at the end of the shaft *l*. When the parts are in the position shown, the shaft *l* is

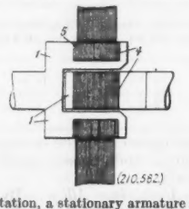






rotated by means of the hand wheel 14 mounted on the shaft 15 to which a worm is made fast. This worm engages the worm wheel *p* which drives the shaft through the clutch members *q*, *t*. When the levers *y* are turned in the direction of the arrows 17 in Fig. 3 (into the position shown in broken lines in that figure) the clutch member *t* is disengaged from the worm wheel *p* in which position the shaft *l* may be rotated by means of the levers *y* through the sleeve *t*. In practice, the brake *g* is applied gradually by means of the hand wheel 14, the worm and wheel *p*, and is retained in the adjusted position by reason of the engagement of the teeth of the wheel *p* by the convolutions of the worm. If at any time it is desirable quickly to apply the brake more strongly, or to release it, this may immediately be done by moving the levers *y* into the dotted line position (see Fig. 3) and by turning the shaft directly by means of those levers. (*Sealed.*)

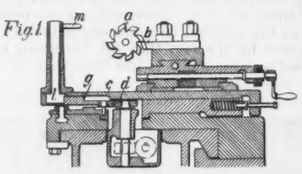
210,582. G. E. Bairsto, South Farnborough. Magneto Electric Generators. (3 *Figs.*) December 9, 1922.—The invention relates to magneto electric generators comprising rotary inductor members or segments having laminations extending in

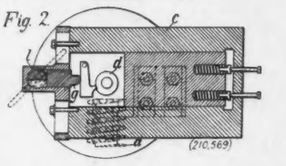


the direction of rotation, a stationary armature and a stationary permanent magnet. According to the invention, in a magneto generator of the inductor type, the inductor members 1 of soft iron are formed with slots or recesses 4 extending in the direction of rotation, and soft iron laminated cores 5 are located in the slots with the laminations lying at right angles to the axis of revolution, by shrink-fitting the inductor members on the laminations. (*Accepted February* 13, 1924.)

MACHINES AND OTHER TOOLS, SHAFTING, &c.

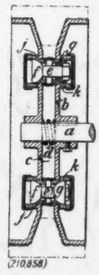
210,569. Smith and Coventry, Limited, Salford, Manchester, and I. H. Wright, Salford, Manchester. Relieving Lathes. (5 *Figs.*) November 24, 1922.—The invention relates to relieving lathes for backing off milling cutters of the type in which the movement of the tool slide is obtained through a cam acting either directly or through a lever upon a projection on the slide; a spring or springs acting on the latter to hold the projection against the cam. In accordance with the invention, the cam *d* acts on an abutment piece *g* which is capable of sliding in a direction parallel to the movement of the reciprocating slide *c*. The abutment *g* is adapted to bear at its rear side





against a rotatable cylinder or thrust block *l* which has an operating handle thereon *m*. The cylinder or thrust block *l* has two flats upon it at different distances from its centre. When the block *l* is turned so that the flat remote from its axis is presented to the abutment *g*, the cam *d* imparts reciprocatory movements to the slide. When, however, the cylinder or block *l* is turned to present the flat which is near to its axis to the abutment *g*, the latter can move out of the range of action of the cam *d* so that the slide *c* comes to rest and the tool *b* moves clear of the workpiece *a* under the action of its springs. (*Accepted February* 13, 1924.)

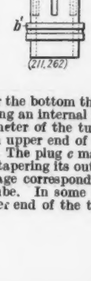
210,858. Roadless Traction, Limited, Hounslow, and O. S. Penn, Wandsworth Common, London. Belt Pulleys. (3 *Figs.*) November 7, 1922.—The invention relates to flanged pulleys which transmit power to or from belts, the pulleys being of the type that are constructed so that any slip between the belt and the pulley automatically retards or speeds up one flange of the pulley in relation to the other flange, thus drawing them closer together and so increasing their grip on the belt. According to the invention, one flange *b*, which is fixed to the



shaft *a*, is connected to another flange *c*, which is loose circumferentially and axially on the shaft, by one or more links. Each link consists of a stem *e* having a spherical portion *j* fixed to one end and another spherical portion *g* secured to the other end. The spherical portions *f* and *g* engage with spherical seats in housings *j* and *k* fixed to or forming part of the flanges *c* and *b*, respectively. A spring *d* is arranged to keep the flanges *b*, *c* normally as far apart as is allowed by the links. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

211,262. Allen Everitt and Sons, Limited, Smethwick, and J. T. Whiteman, Smethwick. Cores for Tube Ingots. (3 *Figs.*) November 30, 1922.—The invention relates to an improved core for use in moulding tube ingots. The invention comprises an inner metallic tube *a* provided with perforations *a*1 for escape of gases, an inner covering of hay, straw, fibre or the like, an outer covering of sand, loam or the like, one or more longitudinal slots *a*2 formed in the perforated tube *a* and extending



from the top end to near the bottom thereof, a loose ring *b* fitting over the upper end having an internal diameter corresponding to that of the normal diameter of the tube, and a removable plug *c* fitting within the open upper end of the tube to keep the tube at its normal diameter. The plug *c* may be securely held within the tube *a* by coning or tapering its outer surface, as shown, or it may be screwed to engage corresponding screw threads formed in the interior of the tube. In some cases a fixed ring *b*1 may be provided on the lower end of the tube *a*. (*Sealed.*)